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Research Article

Additions to the coriaceous families Peniophoraceae and Stereaceae (Russulales): Six novel wood-inhabiting taxa in the genera *Conferticium*, *Gloeocystidiellum*, and *Peniophora* from southwest China

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Abstract

Russulales comprises a highly diverse group of species with respect to basidiomata morphology and hymenophore configuration, in which this order is highly heterogeneous, that can be classified as resupinate, effused-reflexed, discoid, clavarioid, pileate, or stipitate, and with varied hymenophores such as smooth, hydnoid, poroid, and lamellate in different russuloid species. Species in Russulales have been considered to have significant economic value. Six new wood-inhabiting fungi belonging to the genera *Conferticium*, *Gloeocystidiellum*, and *Peniophora* of two families, Peniophoraceae and Stereaceae (Russulales), were found in southwest China. Sequences of ITS+nLSU loci of six new taxa were generated, and phylogenetic analyses were performed with the maximum likelihood, maximum parsimony, and Bayesian inference methods with an emphasis on the phylogeny of wood-inhabiting smooth species in this order. The combined ITS+nLSU loci analysis showed that the six new species grouped within the order Russulales, in which *Conferticium tuberculatum*, *Gloeocystidiellum cremeum*, and *G. fissuratum* grouped into the family Stereaceae, and *Peniophora albohymenia*, *P. hengduanensis*, and *P. punctata* grouped into the family Peniophoraceae. The morphology and multi-gene phylogenetic analyses confirmed the novelty and placement of the six new taxa. Descriptions, illustrations, and phylogenetic analysis results of the new taxa are provided.

Key words: Biodiversity, corticioid fungi, molecular systematics, taxonomy, Yunnan Province

Introduction

The order Russulales Kreisel ex P.M. Kirk, P.F. Cannon & J.C. David is a highly diverse group of the class Agaricomycetes, which includes around 4,436 described species in 98 genera and 11 families (Hyde et al. 2017; Caboň et al. 2019; Vidal et al. 2019; He et al. 2024). Russulales contains not only the

lamellate species like *Russula* Pers. and *Lactarius* Pers. (Herrera et al. 2018; Caboň et al. 2019) but also the poroid, hydnoid, and corticioid representatives like *Asterostroma* Massee, *Hericium* Pers., *Heterobasidion* Bref., and *Peniophora* Cooke (Miller et al. 2006; Chen et al. 2016a; Wu et al. 2020; Yuan et al. 2021; Zhou et al. 2024). In the past few decades, a lot of the new taxa of Russulales have been gathered through both morphological characteristics and DNA sequence phylogenetic analyses (Zhou and Dai 2013; Chen et al. 2015, 2016b; Wu et al. 2020; Zou et al. 2022; Bhunjun et al. 2024; Deng et al. 2024b; Dong et al. 2024; Zhou et al. 2024). Resupinate basidiomata are common in the families Echinodontiaceae, Peniophoraceae, Stereaceae, Terrestriporiaceae, and Xenasmataceae (He et al. 2024; Liu et al. 2024).

The genus *Conferticium* Hallenb. 1980 (Stereaceae, Russulales), typified by *C. insidiosum* (Bourdot & Galzin) Hallenb. (Bernicchia and Gorjón 2010), is characterized by the resupinate basidiomata with membranaceous to ceraceous, smooth to tuberculate hymenophore, a monomitic hyphal system with simple-septate, and numerous cylindrical, sinuous gloeocystidia (Bernicchia and Gorjón 2010). Based on the MycoBank database (http://www.mycobank.org, accessed on 26 February 2025) and the Index Fungorum (http://www.indexfungorum.org, accessed on 26 February 2025), *Conferticium* has registered six specific and infraspecific names; however, only five species are widely recognized (Larsson and Larsson 2003; Bernicchia and Gorjón 2010).

Donk (1931) described *Gloeocystidiellum* (Stereaceae, Russulales), typified by *G. porosum* (Berk. and M.A. Curtis) Donk, as characterized by their resupinate basidiomata with membranaceous to ceraceous, smooth, rarely grandinioid or odontioid hymenophore, a monomitic hyphal system with simple-septate or clamped generative hyphae, and the gloeocystidia numerous, verrucose or aculeate basidiospores (Wu 1996; Bernicchia and Gorjón 2010; Zhao and Zhao 2023). Based on the MycoBank database (http://www.mycobank.org, accessed on 26 February 2025) and the Index Fungorum (http://www.indexfungorum.org, accessed on 26 February 2025), *Gloeocystidiellum* has registered 86 specific and infraspecific names, and the actual number of species is 37 (Zhao and Zhao 2023).

The genus *Peniophora* Cooke (Peniophoraceae, Russulales) was introduced in 1879, typified by *P. quercina* Pers. ex Fr., and it is characterized by the resupinate basidiomata with a smooth hymenophore, a monomitic hyphal system, thin- to thick-walled simple-septate or clamped generative hyphae, dendrohyphidia, lamprocystidia, and gloeocystidia present or absent, and thin-walled, smooth, ellipsoid, cylindrical to allantoid basidiospores negative in Melzer's reagents (Bernicchia and Gorjón 2010; Zou et al. 2022; Xu et al. 2023). Species of the genus prefer to grow on small branches of trees, especially dead but still attached ones in exposed and dry environments (Xu et al. 2023). Based on the MycoBank database (http://www.mycobank.org, accessed on 26 February 2025) and the Index Fungorum (http://www.indexfungorum.org, accessed on 26 February 2025), *Peniophora* was registered with 657 specific and infraspecific names, and the actual number of the species is 211, in which most species have been moved to other genera, and the morphological circumscription of *Peniophora* has been narrowed (Xu et al. 2023). Currently, they occur mainly in the tropical and subtropical areas of the world (Zou et al. 2022; Xu et al. 2023).

Recently, the analysis of DNA sequences has emerged as a common method for deducing fungal phylogenies and enhancing higher classification frameworks through the integration of genetic traits (Wijayawardene et al. 2022, 2024; Dong et al. 2024; He et al. 2022, 2024; Zhang et al. 2023b; Zhao et al. 2023; Zhou et al. 2023; 2025). According to recent research on molecular systematics and divergence times, Basidiomycota is classified into 127 families belonging to 47 orders under 14 classes (He et al. 2024). The family Stereaceae included nineteen genera: *Acanthobasidium*, *Acanthofungus*, *Acanthophysellum*, *Aleurobotrys*, *Aleurodiscus*, *Amylohyphus*, *Amylosporomyces*, *Coniophorafomes*, *Dextrinocystidium*, *Gloeocystidiellum*, *Gloeocystidiopsis*, *Gloeomyces*, *Gloeosoma*, *Megalocystidium*, *Neoaleurodiscus*, *Scotoderma*, *Stereodiscus*, *Stereum*, and *Xylobolus* (Larsson 2007; Vu et al. 2019; He et al. 2024). According to recent research on molecular systematics, the genus *Conferticium* has been reported to have one new taxon, *C. fissuratum* Xin Yang & C.L. Zhao, which is from Yunnan Province, China (Bernicchia and Gorjón 2010; Shen et al. 2024). In the previous study, the phylogenetic relationships among russuloid basidiomycetes were investigated using sequence data from the nuclear 5.8S, ITS2, and large-subunit rDNA genes and elucidated evolutionary relationships within some species of the genus *Gloeocystidiellum* (Larsson and Larsson 2003). The high phylogenetic diversity among corticioid homobasidiomycetes indicated that the species *G. subasperisporum* (Litsch.) J. Erikss. & Ryvarden grouped into the russuloid clade and grouped with the close species *Gloeodontia discolor* (Berk. & M.A. Curtis) Boidin (Larsson et al. 2004). Several morphological and molecular studies as well as cultural studies and intercompatibility tests have analyzed species delimitation in the *Gloeocystidiellum porosum-clavuligerum* group, which revealed that the clade corresponded with two well-distinguished species, *G. kenyense* and *G. clavuligerum* (Telleria et al. 2012). The molecular research carried out on the genus *Gloeocystidiellum*, in which the species *G. granulatum* (Sheng H. Wu) E. Larss. & K.H. Larss and *G. permixtum* (Boidin, Lanq. & Gilles) E. Larss. & K.H. Larss are proposed as new combinations (Larsson et al. 2020). Recently, molecular studies involving *Gloeocystidiellum* based on single-locus or multi-locus datasets have introduced two new taxa, viz. *G. lojanense* A. Jaram., D. Cruz & Decock, and *G. yunnanense* Y.L. Zhao & C.L. Zhao (Jaramillo-Riofrío et al. 2023; Zhao and Zhao 2023).

The genus *Peniophora* Cooke is a large genus of corticioid fungi, which is a cosmopolitan genus with a wide distribution from boreal to tropical areas, causing a white rot on both angiosperms and gymnosperms (Yurchenko 2010; Zou et al. 2022; Xu et al. 2023). Many new lineages and taxa were found and described, and some morphologically dissimilar taxa were proved to be closely related in the phylogeny of *Peniophora* in recent years (Harrington et al. 2021; Lambevska-Hristova 2022; Zou et al. 2022; Xu et al. 2023). The ITS and nLSU sequences of *Peniophora* species, including some from type specimens, were released in GenBank in recent studies and thus made it possible to deeply study the phylogeny of this group (Vu et al. 2019; Zou et al. 2022). The researchers performed the most comprehensive phylogenetic studies using ITS+nLSU datasets, including most of the *Peniophora* species described worldwide (Zou et al. 2022; Xu et al. 2023). Most clades in *Peniophora* are far too resolved, at least considering only ITS or nLSU rDNA regions, and probably a genome full of phylogenetic reconstruction is needed to establish with certitude groups or patterns in the evolution of the different species (Xu et al. 2023; Dong et al. 2024).

Many wood-inhabiting specimens were collected during investigations on wood-inhabiting fungi in the Yunnan-Guizhou Plateau, China. To clarify the placement and relationships of these specimens, we carried out a phylogenetic and taxonomic study based on the ITS+nLSU sequences. These specimens were assigned to the genera *Conferticium*, *Gloeocystidiellum*, and *Peniophora* of the order Russulales. Therefore, six new species, *Conferticium tuberculatum*, *Gloeocystidiellum cremeum*, *G. fissuratum*, *Peniophora albohymenia*, *P. hengduanensis*, and *P. punctata*, are proposed with descriptions and illustrations based on the morphological characteristics and phylogenetic analyses.

Materials and methods

Sample collection and herbarium specimen preparation

Fresh basidiomata of the wood-inhabiting fungi growing on angiosperm branches were collected from the Zhaotong and Diqing of Yunnan Province, China. The samples were photographed *in situ*, and fresh macroscopic details and collection information (Rathnayaka et al. 2024) were recorded. Photographs were taken by a Jianeng 80D camera (Tokyo, Japan). All photos were stacked and merged using Helicon Focus Pro 7.7.5 software. Specimens were dried in an electric food dehydrator at 40 °C, then sealed and stored in an envelope bag and deposited in the herbarium of the Southwest Forestry University (SWFC), Kunming, Yunnan Province, China.

Morphology

Macromorphological descriptions are based on field notes and photos captured in the field and laboratory and follow the color terminology of Petersen (1996). Micromorphological data were obtained from the dried specimens following observation under a light microscope (Zhao et al. 2023a; Dong et al. 2024). The following abbreviations were used: KOH = 5% potassium hydroxide water solution, CB+ = cyanophilous, CB = cotton clue, CB– = acyanophilous, IKI = Melzer's reagent, IKI+ = amyloid, IKI– = both inamyloid and indextrinoid, L = means spore length (arithmetic average for all spores), W = means spore width (arithmetic average for all spores), Q = variation in the L/W ratios between the specimens studied, and n = a/b (number of spores (a) measured from a given number (b) of specimens).

DNA extraction, amplification, and sequencing

The CTAB rapid plant genome extraction kit-DN14 (Aidlab Biotechnologies Co., Ltd., Beijing, China) was used to obtain genomic DNA from dried specimens, according to the previous study (Zhao and Wu 2017). The ITS region was amplified with the primer pair ITS5 and ITS4 (White et al. 1990). The nuclear nLSU region was amplified with primer pair LR0R and LR7 (Vilgalys and Hester 1990). The PCR procedure for ITS was as follows: initial denaturation at 95 °C for 3 min, followed by 35 cycles at 94 °C for 40 s, 54 °C for 45 s, and 72 °C for 1 min; and a final extension at 72 °C for 10 min. The PCR

procedure for nLSU was as follows: initial denaturation at 94 °C for 1 min, followed by 35 cycles at 94 °C for 30 s, 50 °C for 1 min, and 72 °C for 1.5 min, and a final extension at 72 °C for 10 min. The PCR products were purified and sequenced at Kunming Tsingke Biological Technology Limited Company, Kunming, Yunnan Province, P.R. China. All newly generated sequences were deposited in GenBank (Table 1).

Phylogenetic analyses

Sequences were aligned using MAFFT version 7, adjusting the direction of nucleotide sequences according to the first sequence and selecting the G-INS-i iterative refinement method (Katoh et al. 2019). The alignment was adjusted manually using AliView version 1.27 (Larsson 2014). A dataset of concatenated ITS and nLSU sequences was used to determine the phylogenetic position of the six new species. (1) *Vararia tropica* A.L. Welden and *V. yaoshanensis* Y.L. Deng & C.L. Zhao were assigned as outgroups to root trees in the ITS+nLSU analysis (Fig. 1) (Deng et al. 2024b); (2) *Stereum complicatum* (Fr.) Fr. and *S. hirsutum* (Willd.) Pers. were assigned as outgroups to root trees following the ITS+nLSU analysis (Fig. 2) (Maekawa et al. 2023); (3) *Gloeocystidiellum yunnanense* Y.L. Zhao & C.L. Zhao and *G. porosum* Berk. & M.A. Curtis) Donk were assigned as outgroups to root trees following the ITS+nLSU analysis (Fig. 3) (Zhao and Zhao 2023); (4) *Asterostroma rhizomorpharum* H.M. Zhou & C.L. Zhao and *A. yunnanense* Y.L. Deng & C.L. Zhao were assigned as outgroups to root trees following the ITS+nLSU analysis (Fig. 4) (Zhou et al. 2024).

Maximum parsimony (MP), maximum likelihood (ML), and Bayesian inference (BI) analyses were applied to the combined three datasets following the methods outlined in a previous study (Zhao and Wu 2017), and the tree construction procedure was performed in PAUP* version 4.0b10 (Swofford 2002). All characters were equally weighted, and gaps were treated as missing data. Trees were inferred using the heuristic search option with TBR branch swapping and 1,000 random sequence additions. Max-trees were set to 5000, branches of zero length were collapsed, and all parsimonious trees were saved. Clade robustness was assessed using bootstrap (BT) analysis with 1,000 replicates (Felsenstein 1985). Descriptive tree statistics—tree length (TL), consistency index (CI), retention index (RI), rescaled consistency index (RC), and homoplasy index (HI)—were calculated for each maximum parsimonious tree generated. Additionally, the multiple sequence alignment was also analyzed using maximum likelihood (ML) in RAxML-HPC2 through the Cipres Science Gateway (Miller et al. 2012). Branch support (BS) for ML analysis was determined by 1000 bootstrap replicates. jModelTest v2 (Darriba et al. 2012) was used to determine the best-fit evolutionary model for each data set for Bayesian inference (BI), which was performed using MrBayes 3.2.7a (Ronquist et al. 2012). The first one-fourth of all generations was discarded as burn-in. The majority rule consensus tree of all remaining trees was calculated. Branches were considered as significantly supported if they received a maximum likelihood bootstrap value (BS) ≥ 70%, a maximum parsimony bootstrap value (BT) ≥ 50%, or Bayesian posterior probabilities (BPP) ≥ 0.95.

Table 1. Names, voucher numbers, references, and corresponding GenBank accession numbers of the taxa used in the phylogenetic analyses.

Taxa	Voucher	Locality	GenBank accession		Reference
			ITS	nLSU	
Acanthobasidium bambusicola	He2357	China	KU559343	KU574833	Dai and He 2016
Acanthobasidium penicillatum	HHB13223	USA	—	KU574816	Maekawa et al. 2023
Acanthofungus rimosus	Wu 9601-1	China	MF043521	AY039333	Maekawa et al. 2023
Acanthophysellum cerussatum	He 20120920—3	China	KU559339	KU574830	Maekawa et al. 2023
Acanthophysium bisporum	T614	USA	—	AY039327	Maekawa et al. 2023
Acanthophysium lividocaeruleum	FP-100292	USA	—	AY039319	Maekawa et al. 2023
Aleurobotrys botryosus	He2712	China	KX306877	KY450788	Maekawa et al. 2023
Aleurobotrys botryosus	Wu 9302-61	China	—	AY039331	Maekawa et al. 2023
Aleurodiscus bambusinus	He4261	China	KY706207	KY706219	Yan et al. 2018
Aleurodiscus canadensis	Wu1207-90	China	KY706203	KY706225	Yan et al. 2018
Aleurodiscus mirabilis	Dai 13281	China	KU559350	KU574839	Yan et al. 2018
Asterostroma laxum	EL33-99	Estonia	AF506410	AF506410	Larsson and Larsson 2003
Asterostroma muscicola	KHL9537	Puerto Rico	AF506409	AF506409	Larsson and Larsson 2003
Asterostroma rhizomorpharum	CLZhao 31212	China	OR672732	OR879302	Zhou et al. 2024
Asterostroma yunnanense	CLZhao 22781	China	OR048809	OR506285	Deng et al. 2024a
Baltazaria octopodites	FLOR 56449	Brazil	MH260025	MH260047	Leal-Dutra et al. 2018
Conferticium heimii	CBS321.66	African	MH858805	MH858805	Tian et al. 2018
Conferticium ochraceum	CLZhao 21515	China	ON211619	—	Present study
Conferticium ochraceum	G07_P24A	Switzerland	KT943933	—	Stroheker et al. 2018
Conferticium ravum	CBS:125849	Estonia	MH863805	MH875269	Vu et al. 2019
Conferticium ravum	NH13291	USA	AF506382	AF506382	Larsson and Larsson 2003
Conferticium tuberculatum	CLZhao 29376*	China	PQ166602	PQ295861	Present study
Conferticium tuberculatum	CLZhao 29390	China	PQ166603	PQ295862	Present study
Dichostereum effuscatum	GG930915	France	AF506390	AF506390	Larsson and Larsson 2003
Dichostereum pallescens	NH7046/673	Canada	AF506392	AF506392	Larsson and Larsson 2003
Entomocorticium cobbii	B720	USA	MT741707	MT741692	Harrington et al. 2021
Entomocorticium whitneyi	B1069	USA	MT741713	MT741698	Harrington et al. 2021
Gloeocystidiellum aspellum	He4262	China	—	KY860460	Jaramillo-Riofrío et al. 2023
Gloeocystidiellum aspellum	LIN 625	China	AF506432	AF506432	Yan et al. 2018
Gloeocystidiellum bisporum	CBS/961.96	Sweden	AY048875	AY048875	Jaramillo-Riofrío et al. 2023
Gloeocystidiellum bisporum	KHL11135	Norway	AY048877	AY048877	Larsson and Larsson 2003
Gloeocystidiellum clavuligerum	GB/NH11185	Spain	AF310088	AF310088	Jaramillo-Riofrío et al. 2023
Gloeocystidiellum clavuligerum	NH13159/2731	Russia	AF310083	AF310083	Larsson and Larsson 2003
Gloeocystidiellum compactum	Wu880615-21	China	AF506434	AF506434	Maekawa et al. 2023
Gloeocystidiellum cremeum	CLZhao 29477*	China	PQ287846	PQ295863	Present study
Gloeocystidiellum cremeum	CLZhao 33623	China	PQ287847	PQ295864	Present study
Gloeocystidiellum cremeum	CLZhao 33690	China	PQ287848	—	Present study
Gloeocystidiellum fissuratum	CLZhao 32247	China	PQ287849	PQ295865	Present study
Gloeocystidiellum fissuratum	CLZhao 32303	China	PQ287850	PQ295866	Present study
Gloeocystidiellum fissuratum	CLZhao 32498*	China	PQ287851	—	Present study
Gloeocystidiellum formosanum	Wu9404-19	China	AF506439	AF506439	Maekawa et al. 2023
Gloeocystidiellum heimii	LY/CBS321.66	African	AF506381	AF506381	Jaramillo-Riofrío et al. 2023
Gloeocystidiellum kenyense	TFC/15278	Portugal	FR878082	—	Jaramillo-Riofrío et al. 2023
Gloeocystidiellum kenyense	TFC/15309	Portugal	FR878083	—	Jaramillo-Riofrío et al. 2023
Gloeocystidiellum lojanense	HUTPL(F)/2181	Ecuador	OP377059	OP377059	Jaramillo-Riofrío et al. 2023
Gloeocystidiellum lojanense	HUTPL(F)/550	Ecuador	OP377083	OP377083	Jaramillo-Riofrío et al. 2023
Gloeocystidiellum luridum	HK9808	Germany	AF506421	AF506421	Maekawa et al. 2023

Taxa	Voucher	Locality	GenBank accession		Reference
			ITS	nLSU	
Gloeocystidiellum porosum	CBS/51085	Netherlands	AF310097	AF310097	Jaramillo-Riofrío et al. 2023
Gloeocystidiellum porosum	NH 10434	Denmark	AF310094	AF310094	Larsson and Hallenberg 2001
Gloeocystidiellum purpureum	Wu9310-45	China	AF441338	AF441338	Larsson and Hallenberg 2001
Gloeocystidiellum rajchenbergii	GB/NH16348	Chile	JQ734555	—	Jaramillo-Riofrío et al. 2023
Gloeocystidiellum rajchenbergii	GB/NH16358	Chile	JQ734554	—	Jaramillo-Riofrío et al. 2023
Gloeocystidiellum triste	KHL10334	Sweden	AF506442	AF506442	Maekawa et al. 2023
Gloeocystidiellum yunnanense	CLZhao 7165	China	MZ710569	MZ710571	Zhao and Zhao 2023
Gloeocystidiellum yunnanense	CLZhao 7202	China	MZ710570	MZ710572	Zhao and Zhao 2023
Gloeocystidiopsis flammea	CBS:324.66	African	AF506437	AF506437	Larsson and Larsson 2003
Gloeocystidiopsis heimii	CBS:321.66	Sweden	AF506381	AF506381	Larsson and Larsson 2003
Gloiothele lactescens	EL8-98	Sweden	AF506453	AF506453	Larsson and Larsson 2003
Gloiothele lamellosa	KHL11031	Venezuela	AF506454	AF506454	Larsson and Larsson 2003
Lachnocladium schweinfurthianum	KM 49740	Cameroon	MH260033	MH260051	Leal-Dutra et al. 2018
Megalocystidium chelidonium	LodgeSJ110.1	USA	AF506441	AF506441	Larsson and Larsson 2003
Megalocystidium diffissum	V.Spirin4244	Sweden	MT477147	MT477147	Maekawa et al. 2023
Megalocystidium leucoxanthum	HK9808	Sweden	AF506420	AF506420	Maekawa et al. 2023
Metulodontia nivea	NH13108	Russia	AF506423	AF506423	Larsson and Larsson 2003
Neoaleurodiscus fujii	He2921	China	KU559357	KU574845	Dai et al. 2017
Neoaleurodiscus fujii	Wu0807-41	Japan	—	FJ799924	Dai et al. 2017
Parapterulicium subarbusculum	FLOR 56456	Brazil	MH260026	MH260048	Leal-Dutra et al. 2018
Peniophora albobadia	CBS:329.66	France	MH858809	MH870448	Vu et al. 2019
Peniophora albobadia	He2159	USA	MK588755	MK588795	Xu et al. 2023
Peniophora albohymenia	CLZhao 23473*	China	PQ066419	PQ295867	Present study
Peniophora aurantiaca	CBS:396.50	France	MH856678	MH868195	Vu et al. 2019
Peniophora aurantiaca	UBCF:19732	Canada	HQ604854	HQ604854	Xu et al. 2023
Peniophora bicornis	He3609	China	MK588763	MK588803	Xu et al. 2023
Peniophora bicornis	He4767	China	MK588764	MK588804	Xu et al. 2023
Peniophora borbonica	He4597	China	MK588766	MK588806	Xu et al. 2023
Peniophora borbonica	He4606	China	MK588765	MK588805	Xu et al. 2023
Peniophora cinerea	CLZhao 23390	China	PQ166604	PQ295868	Present study
Peniophora cinerea	He3725	China	MK588769	MK588809	Xu et al. 2023
Peniophora crassitunicata	CLZhao 29461	China	PQ166605	PQ295869	Present study
Peniophora crassitunicata	He3814	China	MK588770	MK588810	Xu et al. 2023
Peniophora cremicolor	He5380	China	MK588791	MK588831	Xu et al. 2023
Peniophora duplex	CBS:286.58	Canada	MH857787	MH869321	Vu et al. 2019
Peniophora duplex	TPDuB1022	USA	AF119519	—	Harrington and Hsaiu 2003
Peniophora erikssonii	CBS:287.58	France	MH857788	MH869322	Vu et al. 2019
Peniophora erikssonii	Cui 11871	China	MK588771	MK588811	Xu et al. 2023
Peniophora exima	T-523	USA	MK588772	MK588812	Xu et al. 2023
Peniophora fasticata	CBS:942.96	Ethiopia	MH862624	—	Vu et al. 2019
Peniophora fissilis	CBS:681.91	Reunion	MH862298	MH873975	Vu et al. 2019
Peniophora fissilis	CBS:684.91	Mascarene Islands	MH862299	MH873976	Vu et al. 2019
Peniophora gilbertsonii	CBS:357.95	USA	MH862528	MH874164	Vu et al. 2019
Peniophora gilbertsonii	CBS:360.95	USA	MH862530	MH874165	Vu et al. 2019
Peniophora guadelupensis	CBS:715.91	Guadeloupe	MH862304	MH873977	Vu et al. 2019
Peniophora halimi	CBS:863.84	France	MH861844	MH873532	Vu et al. 2019
Peniophora halimi	CBS:864.84	France	MH861845	MH873533	Vu et al. 2019
Peniophora hengduanensis	CLZhao 34697*	China	PQ066422	PQ295870	Present study
Peniophora incarnata	CBS:398.50	France	MH856680	MH868197	Vu et al. 2019
Peniophora incarnata	CBS:399.50	France	MH856681	MH868198	Vu et al. 2019

Taxa	Voucher	Locality	GenBank accession		Reference
			ITS	nLSU	
Peniophora junipericola	CBS:349.54	Sweden	MH857354	—	Vu et al. 2019
Peniophora junipericola	He2462	China	MK588773	MK588813	Xu et al. 2023
Peniophora kuehneri	CBS:719.91	Mascarene Islands	MH862307	MH873980	Vu et al. 2019
Peniophora kuehneri	He4745	China	MK588757	MK588797	Xu et al. 2023
Peniophora kuehneroides	CBS:731.91	Mascarene Islands	MH862317	MH873989	Vu et al. 2019
Peniophora kuehneroides	CBS:732.91	Mascarene Islands	MH862318	MH873990	Vu et al. 2019
Peniophora laete	CBS:256.56	France	MH857617	MH869165	Vu et al. 2019
Peniophora lassa	He3052	China	MK588758	MK588798	Xu et al. 2023
Peniophora lassa	SP6129	Russia	KJ509191	—	Spirin and Kout 2015
Peniophora laxitexta	BAFC 3309	Argentina	FJ882040	—	Robles et al. 2011
Peniophora laxitexta	LGMF1159	Argentina	JX559580	—	Xu et al. 2023
Peniophora lilacea	CBS:337.66	Armenia	MH858813	MH870452	Vu et al. 2019
Peniophora limitata	olrim 963	Lithuania	AY787678	—	Lygis et al. 2005
Peniophora lycii	Boid-437	France	MK588774	MK588814	Xu et al. 2023
Peniophora lycii	CBS:264.56	France	MH857624	MH869169	Vu et al. 2019
Peniophora major	He5528	China	MK588792	MK588832	Xu et al. 2023
Peniophora malaiensis	CBS:679.91	Singapore	MH862297	MH873974	Vu et al. 2019
Peniophora malaiensis	CLZhao 23595	China	PQ166607	PQ295871	Present study
Peniophora manshurica	He2956	China	MK588776	MK588816	Xu et al. 2023
Peniophora manshurica	He3729	China	MK588777	MK588817	Xu et al. 2023
Peniophora meridionalis	CBS:289.58	France	MH857789	MH869323	Vu et al. 2019
Peniophora molesta	CBS:676.91	Gabon	MH862294	MH873973	Vu et al. 2019
Peniophora molesta	CBS:677.91	Gabon	MH862295	—	Vu et al. 2019
Peniophora monticola	CBS:649.91	Reunion	MH862289	MH873970	Vu et al. 2019
Peniophora nuda	CLZhao 23406	China	PQ166608	PQ295872	Present study
Peniophora nuda	He5280	China	MK588778	MK588818	Xu et al. 2023
Peniophora ovalispora	CBS:653.91	Mascarene Islands	MH862290	MH873971	Vu et al. 2019
Peniophora parvocystidiata	CBS:716.91	Guadeloupe	MH862305	MH873978	Vu et al. 2019
Peniophora piceae	209	Russia	JX507718	—	Grum-Grzhimaylo et al. 2016
Peniophora piceae	olrim10	Sweden	AY781264	—	Vasiliauskas et al. 2005
Peniophora pilatiana	CBS:265.56	France	MH857625	MH869170	Vu et al. 2019
Peniophora pilatiana	CBS -A1/A2	China	MK588780	MK588820	Xu et al. 2023
Peniophora pini	CBS:274.56	France	MH857632	MH869177	Vu et al. 2019
Peniophora pini	Hjm 18143	Sweden	EU118651	EU118651	Larsson 2007
Peniophora pithya	CBS:277.56	France	MH857635	MH869180	Vu et al. 2019
Peniophora pithya	He3107	China	MK588781	MK588821	Xu et al. 2023
Peniophora polygonia	CBS:404.50	France	MH856684	MH868201	Vu et al. 2019
Peniophora polygonia	He4651	China	MK588782	MK588822	Xu et al. 2023
Peniophora proxima	CBS:405.50	France	MH856685	MH868202	Vu et al. 2019
Peniophora proxima	He5498	China	MK588783	MK588823	Xu et al. 2023
Peniophora pseudopini	DAOM-30124-Sp	Canada	MK588784	MK588824	Xu et al. 2023
Peniophora pseudopini	TPPpB1007	USA	AF119514	—	Leal-Dutra et al. 2018
Peniophora punctata	CLZhao 33769*	China	PQ066418	—	Present study
Peniophora quercina	CBS:408.50	France	MH856688	MH868205	Vu et al. 2019
Peniophora quercina	CBS:407.50	France	MH856687	MH868204	Vu et al. 2019
Peniophora reidii	CBS:397.83	France	MH861616	MH873334	Vu et al. 2019
Peniophora rhoica	CBS:943.96	Ethiopia	MH862625	MH874246	Vu et al. 2019
Peniophora roseoalba	CLZhao 31523	China	PQ166609	PQ295873	Present study

Taxa	Voucher	Locality	GenBank accession		Reference
			ITS	nLSU	
Peniophora roseoalba	CLZhao 3513	China	ON786559	OP380690	Zou et al. 2022
Peniophora rufa	CBS:351.59	Canada	MH857891	MH869432	Vu et al. 2019
Peniophora rufa	He2788	China	MK588786	MK588826	Xu et al. 2023
Peniophora rufomarginata	CBS:281.56	France	MH857639	MH869183	Vu et al. 2019
Peniophora rufomarginata	CBS:282.56	France	MH857640	MH869184	Vu et al. 2019
Peniophora septentrionalis	CBS:294.58	Canada	MH857791	MH869325	Vu et al. 2019
Peniophora shenghuae	CLZhao 23654	China	PQ066420	—	Present study
Peniophora shenghuae	CLZhao 35044	China	PQ066421	—	Present study
Peniophora shenghuae	He3507	China	MK588788	MK588828	Xu et al. 2023
Peniophora shenghuae	He5447	China	MK588790	MK588830	Xu et al. 2023
Peniophora simulans	CBS:874.84	France	MH861849	MH873537	Vu et al. 2019
Peniophora simulans	CBS:875.84	France	MH861850	MH873538	Vu et al. 2019
Peniophora sphaerocystidiata	HHB-8827-Sp	USA	MK588787	MK588827	Xu et al. 2023
Peniophora subsalmonea	CBS:696.91	Mascarene Islands	MH862302	—	Vu et al. 2019
Peniophora subsalmonea	CBS:697.91	Mascarene Islands	MH862303	—	Vu et al. 2019
Peniophora taiwanensis	Wu9206-28	China	MK588793	MK588833	Xu et al. 2023
Peniophora taiwanensis	Wu9209-14	China	MK588794	MK588834	Xu et al. 2023
Peniophora tamaricicola	CBS:438.62	Morocco	MH858203	MH869802	Vu et al. 2019
Peniophora tamaricicola	CBS:439.62	Morocco	MH858204	MH869803	Vu et al. 2019
Peniophora trigonosperma	CBS:402.83	France	MH861618	MH873335	Vu et al. 2019
Peniophora trigonosperma	He3602	China	MK588762	MK588802	Xu et al. 2023
Peniophora tristicula	CBS:210.63	Pakistan	MH858266	—	Vu et al. 2019
Peniophora tristicula	He4775	China	MH669235	MH669239	Liu and He 2018
Peniophora versicolor	CBS:358.61	Morocco	MH858082	MH869651	Vu et al. 2019
Peniophora versiformis	CBS:358.54	France	MH857360	MH868902	Vu et al. 2019
Peniophora versiformis	He3029	China	MK588756	MK588796	Xu et al. 2023
Peniophora vietnamensis	He5242	Vietnam	MK588761	MK588801	Xu et al. 2023
Peniophora vietnamensis	He5252	Vietnam	MK588761	MK588801	Xu et al. 2023
Peniophora violaceolivida	CBS:348.52	France	MH857077	MH868613	Vu et al. 2019
Peniophora yunnanensis	CLZhao 7347	China	OP380616	—	Zou et al. 2022
Peniophora yunnanensis	CLZhao 3978	China	OP380617	OP380689	Zou et al. 2022
Scytinostroma acystidiatum	CLZhao 32022	China	PQ166610	PQ295874	Present study
Scytinostroma acystidiatum	Dai 24608	China	OQ689127	OQ629351	Zhang et al. 2023
Scytinostroma bambusinum	CLZhao 32789	China	PQ166599	PQ295875	Present study
Scytinostroma bambusinum	JXH 643	China	OR510627	PP660872	Ji et al. 2024
Scytinostroma macrospermum	Dai 24606	China	OQ689126	OQ629350	Wang et al. 2020
Scytinostroma portentosum	EL11-99	Sweden	AF506470	AF506470	Larsson and Larsson 2003
Stereodiscus limonisporus	CBS:125846	New Zealand	—	MH875266	Maekawa et al. 2023
Stereum complicatum	He2234	China	KU559368	KU574828	Maekawa et al. 2023
Stereum hirsutum	Wu1109–127	China	LC430906	LC430909	Maekawa et al. 2023
Stereum sanguinolentum	He2111	China	KU559367	KU574827	Maekawa et al. 2023
Vararia fissurata	CLZhao 8171	China	OQ025219	OR539503	Deng et al. 2024b
Vararia investiens	TAA164122	Norway	AF506484	AF506484	Larsson and Larsson 2003
Vararia tropica	CBS:704.81	France	MH861447	MH873189	Vu et al. 2019
Vararia yaoshanensis	CLZhao 20693	China	PP091665	PP091684	Deng et al. 2024b
Vesiculomyces citrinus	EL53-97	Sweden	AF506486	AF506486	Deng et al. 2024b
Xylobolus frustulatus	He2231	USA	KU881905	KU574825	Maekawa et al. 2023
Xylobolus subpileatus	FP-106735	USA	—	AY039309	Maekawa et al. 2023

* indicates type materials; — indicates sequence unavailability.

Result

The phylogeny of Stereaceae

The dataset based on ITS+nLSU (Fig. 1) comprises sequences from 44 fungal specimens representing 35 species from GenBank. The dataset had an aligned length of 2,136 characters, of which 1,324 characters are constant, 250 are variable and parsimony-uninformative, and 562 are parsimony-informative. Maximum parsimony analysis yielded five equally parsimonious trees (TL = 2,504, CI = 0.5112, HI = 0.4888, RI = 0.6001, RC = 0.3068). The best model for the ITS+nLSU dataset estimated and applied in the Bayesian analysis was GTR+I+G. The phylogenetic tree (Fig. 1) inferred from ITS+nLSU sequences revealed that *Conferticium tuberculatum*, *Gloeocystidiellum cremeum*, and *G. fissuratum* grouped into the family Stereaceae.

The phylogeny of *Gloeocystidiellum*

The dataset based on ITS+nLSU (Fig. 2) comprises sequences from 31 fungal specimens representing 18 species from GenBank. The dataset had an aligned length of 2,154 characters, of which 1,605 characters are constant, 131 are variable and parsimony-uninformative, and 418 are parsimony-informative. Maximum parsimony analysis yielded five equally parsimonious trees (TL = 1,039, CI = 0.7372, HI = 0.2628, RI = 0.8640, RC = 0.6370). The best model for the ITS+nLSU dataset estimated and applied in the Bayesian analysis was GTR+I+G. The phylogenetic tree (Fig. 2) inferred from ITS+nLSU sequences revealed that *Gloeocystidiellum cremeum* and *G. fissuratum* grouped into the genus *Gloeocystidiellum*.

The phylogeny of Peniophoraceae

The dataset based on ITS+nLSU (Fig. 3) comprises sequences from 36 fungal specimens representing 34 species from GenBank. The dataset had an aligned length of 2,375 characters, of which 1,345 characters are constant, 304 are variable and parsimony-uninformative, and 726 are parsimony-informative. Maximum parsimony analysis yielded five equally parsimonious trees (TL = 3,317, CI = 0.5246, HI = 0.4754, RI = 0.6349, RC = 0.3330). The best model for the ITS+nLSU dataset estimated and applied in the Bayesian analysis was GTR+I+G. The phylogenetic tree (Fig. 3) inferred from ITS+nLSU sequences revealed that *Peniophora albohymenia*, *P. hengduanensis*, and *P. punctata* grouped into the family Peniophoraceae.

The phylogeny of *Peniophora*

The dataset based on ITS+nLSU (Fig. 4) comprises sequences from 110 fungal specimens representing 66 species from GenBank. The dataset had an aligned length of 2,006 characters, of which 1,389 characters are constant, 194 are variable and parsimony-uninformative, and 423 are parsimony-informative. Maximum parsimony analysis yielded five equally parsimonious trees (TL = 2,470, CI = 0.3441, HI = 0.6559, RI = 0.6067, RC = 0.2088). The best model for the ITS+nLSU dataset estimated and applied in the Bayesian analysis was SYM+I+G. The phylogenetic tree (Fig. 4) inferred from ITS+nLSU sequences revealed that *Peniophora albohymenia*, *P. hengduanensis*, and *P. punctata* grouped into the genus *Peniophora*.

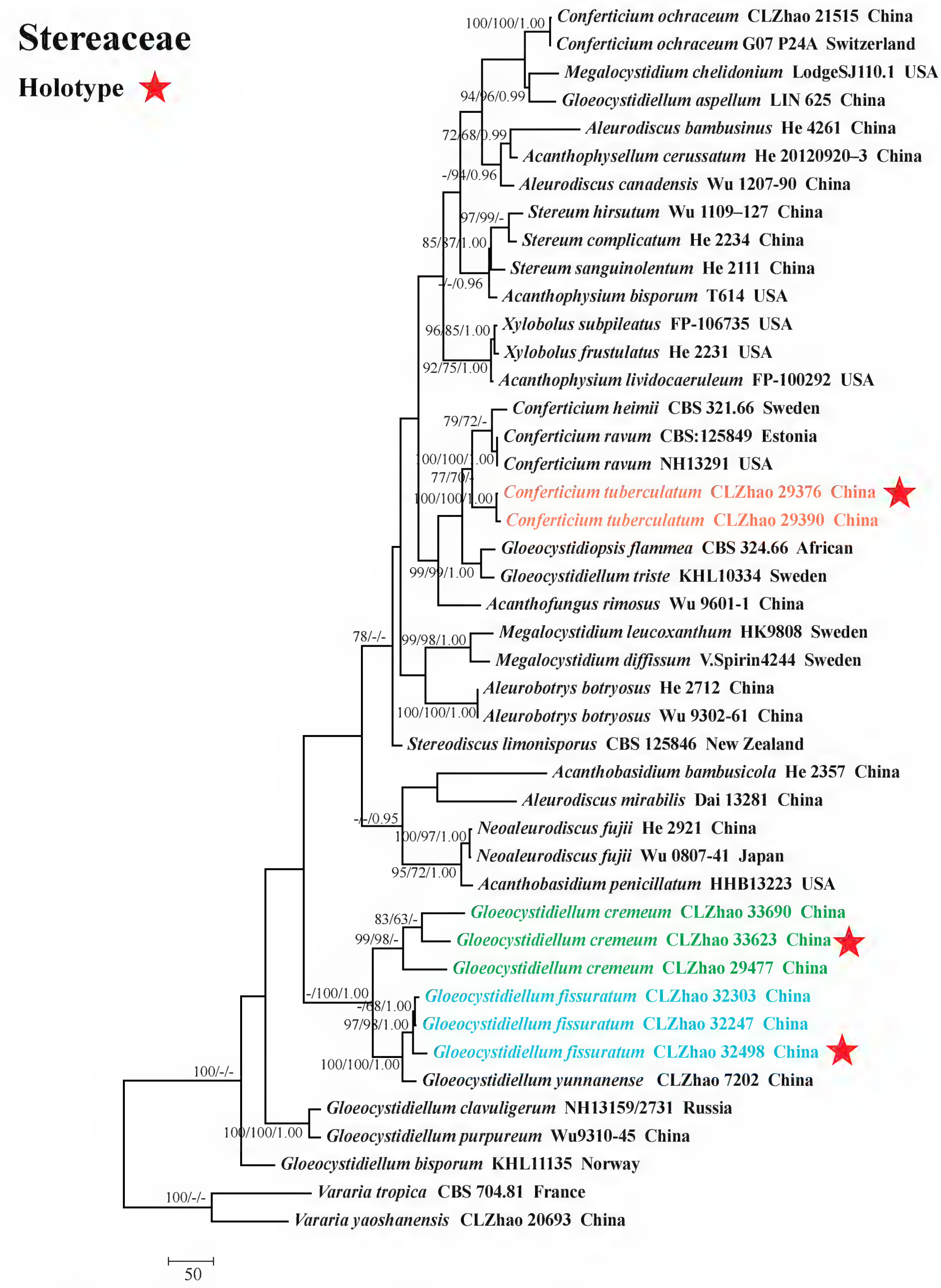

Figure 1. Maximum parsimony strict consensus tree illustrating the phylogeny of *Conferticium* and *Gloeocystidiellum* and related genera in the family Stereaceae, based on ITS+nLSU sequences; branches are labeled with maximum likelihood bootstrap value ≥ 70%, parsimony bootstrap value ≥ 50%, and Bayesian posterior probabilities ≥ 0.95.

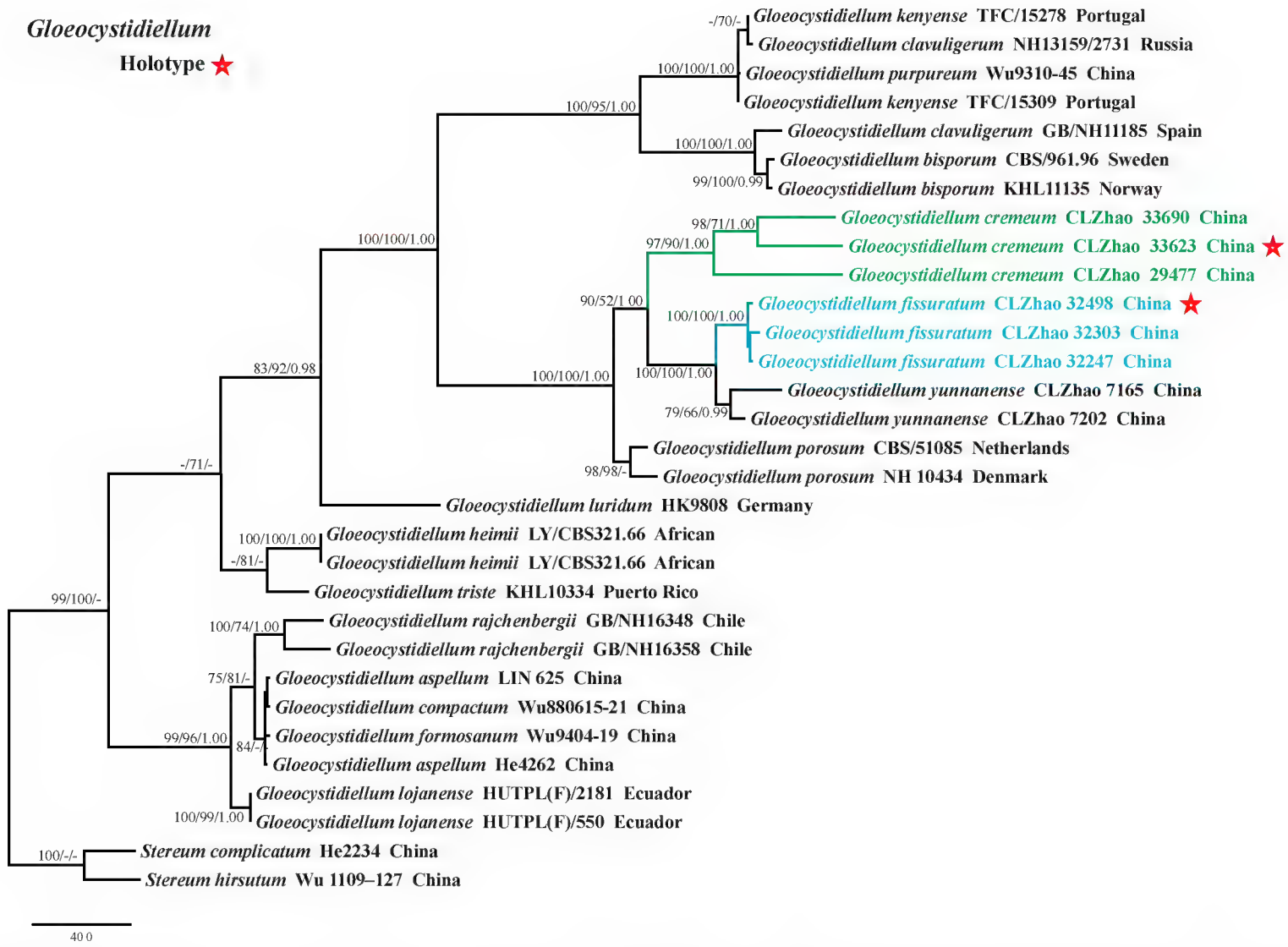
Gloeocystidiellum
Holotype
Gloeocystidiellum kenyense TFC/15278 Portugal
Gloeocystidiellum clavuligerum NH13159/2731 Russia
Gloeocystidiellum purpureum Wu9310-45 China
Gloeocystidiellum kenyense TFC/15309 Portugal
Gloeocystidiellum clavuligerum GB/NH11185 Spain
Gloeocystidiellum bisporum CBS/961.96 Sweden
Gloeocystidiellum bisporum KHL11135 Norway
Gloeocystidiellum cremeum CLZhao 33690 China
Gloeocystidiellum cremeum CLZhao 33623 China
Gloeocystidiellum cremeum CLZhao 29477 China
Gloeocystidiellum fissuratum CLZhao 32498 China
Gloeocystidiellum fissuratum CLZhao 32303 China
Gloeocystidiellum fissuratum CLZhao 32247 China
Gloeocystidiellum yunnanense CLZhao 7165 China
Gloeocystidiellum yunnanense CLZhao 7202 China
Gloeocystidiellum porosum CBS/51085 Netherlands
Gloeocystidiellum porosum NH 10434 Denmark
Gloeocystidiellum luridum HK9808 Germany
Gloeocystidiellum heimii LY/CBS321.66 African
Gloeocystidiellum heimii LY/CBS321.66 African
Gloeocystidiellum triste KHL10334 Puerto Rico
Gloeocystidiellum rajchenbergii GB/NH16348 Chile
Gloeocystidiellum rajchenbergii GB/NH16358 Chile
Gloeocystidiellum aspellum LIN 625 China
Gloeocystidiellum compactum Wu880615-21 China
Gloeocystidiellum formosanum Wu9404-19 China
Gloeocystidiellum aspellum He4262 China
Gloeocystidiellum lojanense HUTPL(F)/2181 Ecuador
Gloeocystidiellum lojanense HUTPL(F)/550 Ecuador
Stereum complicatum He2234 China
Stereum hirsutum Wu 1109–127 China
40 0

Figure 2. Maximum parsimony strict consensus tree illustrating the phylogeny of two new species and related species in the genus *Gloeocystidiellum*, based on ITS+nLSU sequences; branches are labeled with maximum likelihood bootstrap value ≥ 70%, parsimony bootstrap value ≥ 50%, and Bayesian posterior probabilities ≥ 0.95.

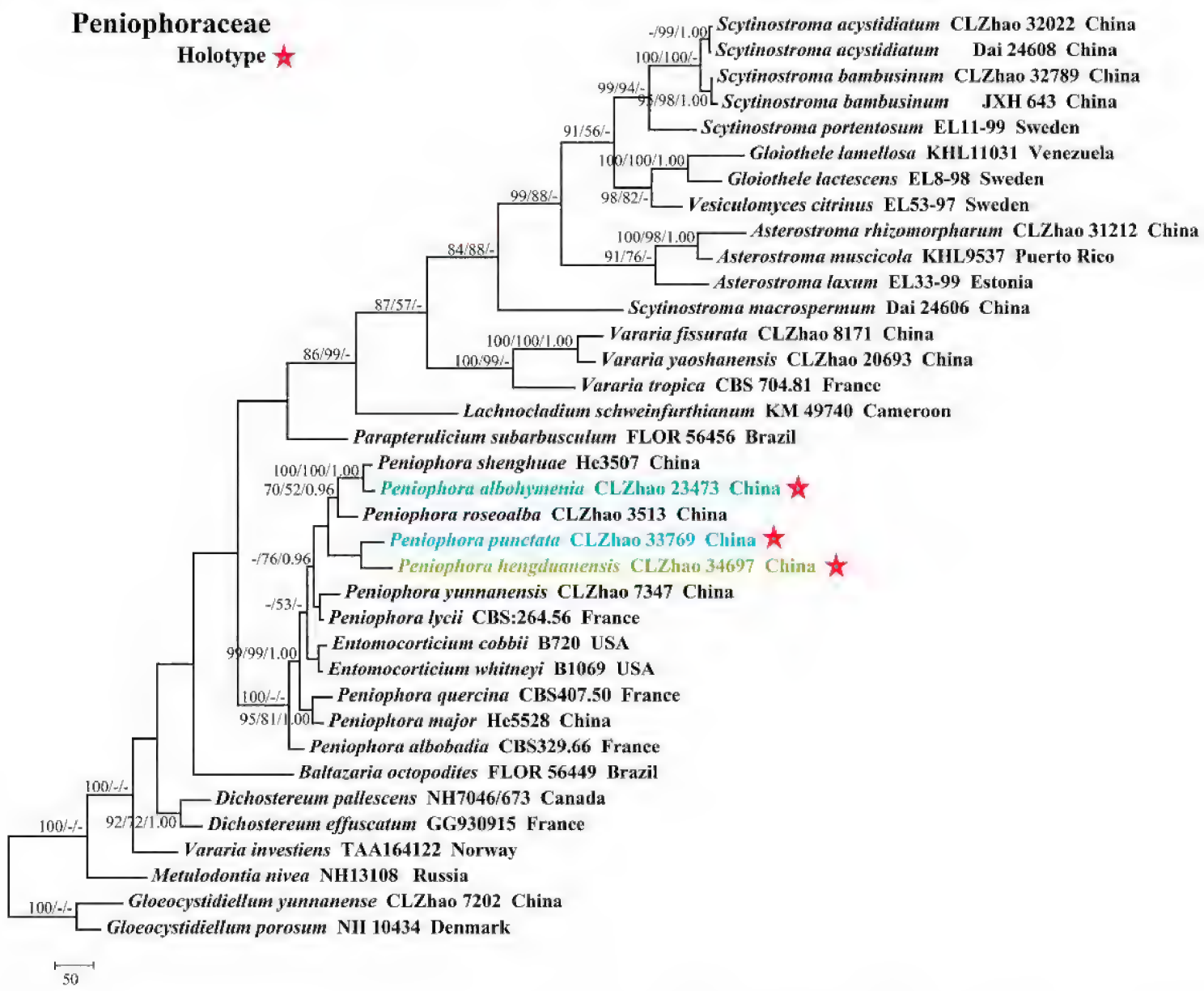
Peniophoraceae
Holotype
Scytinostroma acystidiatum CLZhao 32022 China
Scytinostroma acystidiatum Dai 24608 China
Scytinostroma bambusinum CLZhao 32789 China
Scytinostroma bambusinum JXH 643 China
Scytinostroma portentosum EL11-99 Sweden
Gloiothele lamellosa KHL11031 Venezuela
Gloiothele lactescens EL8-98 Sweden
Vesiculomyces citrinus EL53-97 Sweden
Asterostroma rhizomorpharum CLZhao 31212 China
Asterostroma muscicola KHL9537 Puerto Rico
Asterostroma laxum EL33-99 Estonia
Scytinostroma macrospermum Dai 24606 China
Vararia fissurata CLZhao 8171 China
Vararia yaoshanensis CLZhao 20693 China
Vararia tropica CBS 704.81 France
Lachnocladium schweinfurthianum KM 49740 Cameroon
Parapterulicium subarbusculum FLOR 56456 Brazil
Peniophora shenghuae He3507 China
Peniophora albohymenia CLZhao 23473 China
Peniophora roseoalba CLZhao 3513 China
Peniophora punctata CLZhao 33769 China
Peniophora hengduanensis CLZhao 34697 China
Peniophora yunnanensis CLZhao 7347 China
Peniophora lycii CBS:264.56 France
Entomocorticium cobbii B720 USA
Entomocorticium whitneyi B1069 USA
Peniophora quercina CBS407.50 France
Peniophora major He5528 China
Peniophora albobadia CBS329.66 France
Baltazaria octopodites FLOR 56449 Brazil
Dichostereum pallescens NH7046/673 Canada
Dichostereum effuscatum GG930915 France
Vararia investiens TAA164122 Norway
Metulodontia nivea NH13108 Russia
Gloeocystidiellum yunnanense CLZhao 7202 China
Gloeocystidiellum porosum NH 10434 Denmark
50

Figure 3. Maximum parsimony strict consensus tree illustrating the phylogeny of *Peniophora* and related genera in the family Peniophoraceae, based on ITS+nLSU sequences; branches are labeled with maximum likelihood bootstrap value ≥ 70%, parsimony bootstrap value ≥ 50%, and Bayesian posterior probabilities ≥ 0.95.

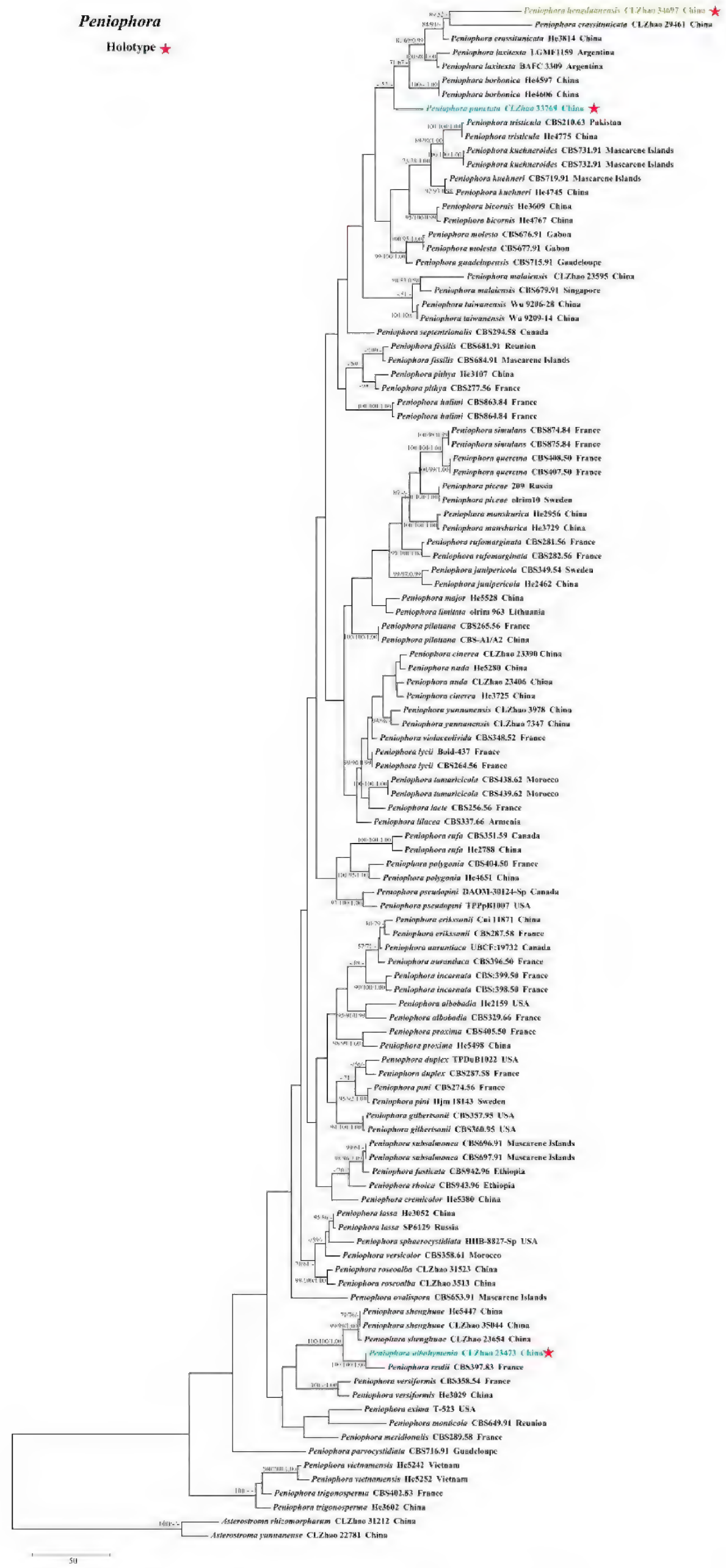
Peniophora
Holotype
Peniophora hengduanensis CLZhao 34697 China
Peniophora crassitunicata CLZhao 29461 China
Peniophora crassitunicata He3814 China
Peniophora laxitexta LGMF1159 Argentina
Peniophora laxitexta BAFC 3349 Argentina
Peniophora borbonica He4597 China
Peniophora borbonica He4606 China
Peniophora punctata CLZhao 33769 China
Peniophora tristicula CBS210.63 Pakistan
Peniophora tristicula He4775 China
Peniophora kuehneroides CBS731.91 Mascarene Islands
Peniophora kuehneroides CBS732.91 Mascarene Islands
Peniophora kuehneri CBS719.91 Mascarene Islands
Peniophora kuehneri He4745 China
Peniophora bicornis He3609 China
Peniophora bicornis He4767 China
Peniophora molesta CBS676.91 Gabon
Peniophora molesta CBS677.91 Gabon
Peniophora guadelupensis CBS715.91 Guadeloupe
Peniophora malaiensis CLZhao 23595 China
Peniophora malaiensis CBS679.91 Singapore
Peniophora taiwanensis Wu 9206-28 China
Peniophora taiwanensis Wu 9209-14 China
Peniophora septentrionalis CBS294.58 Canada
Peniophora fissilis CBS681.91 Reunion
Peniophora fissilis CBS684.91 Mascarene Islands
Peniophora pithya He3107 China
Peniophora pithya CBS277.56 France
Peniophora hallii CBS863.84 France
Peniophora hallii CBS864.84 France
Peniophora simulans CBS874.84 France
Peniophora simulans CBS875.84 France
Peniophora quercina CBS408.50 France
Peniophora quercina CBS407.50 France
Peniophora piceae 209 Russia
Peniophora piceae olrim10 Sweden
Peniophora manshurica He2956 China
Peniophora manshurica He3729 China
Peniophora rufomarginata CBS281.56 France
Peniophora rufomarginata CBS282.56 France
Peniophora junipericola CBS349.54 Sweden
Peniophora junipericola He2462 China
Peniophora major He5528 China
Peniophora limitata olrim 963 Lithuania
Peniophora pilatiana CBS265.56 France
Peniophora pilatiana CBS-A1/A2 China
Peniophora cinerea CLZhao 23390 China
Peniophora nuda He5280 China
Peniophora nuda CLZhao 23406 China
Peniophora cinerea He3725 China
Peniophora yunnanensis CLZhao 3978 China
Peniophora yunnanensis CLZhao 7347 China
Peniophora violaceolivida CBS348.52 France
Peniophora lycii Bold-437 France
Peniophora lycii CBS264.56 France
Peniophora tamaricicola CBS438.62 Morocco
Peniophora tamaricicola CBS439.62 Morocco
Peniophora laete CBS256.56 France
Peniophora lilacea CBS337.66 Armenia
Peniophora rufa CBS351.59 Canada
Peniophora rufa He2788 China
Peniophora polygonia CBS404.50 France
Peniophora polygonia He4651 China
Peniophora pseudopini DAOM-30124-Sp Canada
Peniophora pseudopini TFPpB1007 USA
Peniophora eriksonii Cui 11871 China
Peniophora eriksonii CBS287.58 France
Peniophora aurantiaca UBCF:19732 Canada
Peniophora aurantiaca CBS396.50 France
Peniophora incarnata CBS:399.50 France
Peniophora incarnata CBS:398.50 France
Peniophora albobadia He2159 USA
Peniophora albobadia CBS329.66 France
Peniophora proxima CBS405.50 France
Peniophora proxima He5498 China
Peniophora duplex TPDuB1022 USA
Peniophora duplex CBS287.58 France
Peniophora pini CBS274.56 France
Peniophora pini Hjm 18143 Sweden
Peniophora gilbertsonii CBS357.95 USA
Peniophora gilbertsonii CBS360.95 USA
Peniophora sahsalmonea CBS696.91 Mascarene Islands
Peniophora sahsalmonea CBS697.91 Mascarene Islands
Peniophora fasticata CBS942.96 Ethiopia
Peniophora rhoica CBS943.96 Ethiopia
Peniophora cremicolor He5380 China
Peniophora lassa He3052 China
Peniophora lassa SP6129 Russia
Peniophora sphaerocystidiata HHB-8827-Sp USA
Peniophora versicolor CBS358.61 Morocco
Peniophora roseoalba CLZhao 31523 China
Peniophora roseoalba CLZhao 3513 China
Peniophora ovalispora CBS653.91 Mascarene Islands
Peniophora shenghuae He5447 China
Peniophora shenghuae CLZhao 35044 China
Peniophora shenghuae CLZhao 23654 China
Peniophora albohymenia CLZhao 23423 China
Peniophora rezdii CBS397.83 France
Peniophora versiformis CBS358.54 France
Peniophora versiformis He3029 China
Peniophora exilua T-523 USA
Peniophora monticola CBS649.91 Reunion
Peniophora meridionalis CBS289.58 France
Peniophora parvocystidiata CBS716.91 Guadeloupe
Peniophora vietnamensis He5242 Vietnam
Peniophora vietnamensis He5252 Vietnam
Peniophora trigonosperma CBS402.83 France
Peniophora trigonosperma He3602 China
Asterostroma rhizomorpharum CLZhao 31212 China
Asterostroma yunnanense CLZhao 22781 China
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Figure 4. Maximum parsimony strict consensus tree illustrating the phylogeny of three new species and related species in the genus *Peniophora*, based on ITS+nLSU sequences; branches are labeled with maximum likelihood bootstrap value ≥ 70%, parsimony bootstrap value ≥ 50%, and Bayesian posterior probabilities ≥ 0.95.

Taxonomy

***Conferticium tuberculatum* L. Wang & C.L. Zhao, sp. nov.**
MycoBank No: 855872
Figs 5, 6

Typification. China. • Yunnan Province: Zhaotong, Daguan County, Huanglianhe Scenic Spot, GPS coordinates: 27°72'N, 103°92'E, altitude: 1480 m asl., on the fallen angiosperm branch, leg. C.L. Zhao, 3 Jul 2023, CLZhao 29376, GenBank: ITS = PQ166602, nLSU = PQ295861 (SWFC!).

Diagnosis. It is characterized by coriaceous basidiomata with tuberculate hymenophore surface, a monomitic hyphal system with simple-septa generative hyphae, and ellipsoid to broadly ellipsoid basidiospores.

Etymology. *Tuberculatum* (Lat.): refers to the species having the tuberculate basidiomata.

Description. *Basidiomata*. Annual, resupinate, closely adnate, coriaceous, without odor or taste when fresh, up to 10 cm long, 3 cm wide, and 400 μm thick. Hymenophore tuberculate, white when fresh, white to cream upon drying. Sterile margin narrow, white to cream, up to 1 mm.

***Hyphal system*.** Monomitic; generative hyphae simple-septate, colorless, thin-walled, smooth, rarely branched, interwoven, 3–3.5 μm in diameter, IKI+, CB–; tissues unchanged in KOH.

***Hymenium*.** Gloeocystidia of two types: (1) fusiform, often with an apical appendix, flexuous, colorless, thin-walled, smooth, 34–46 × 7–9 μm; (2) clavate, colorless, thin-walled, smooth, 36–39 × 7–8 μm. Basidia subcylindrical to subclavate, slightly flexuous, with a basal simple septum and four sterigmata, 33.5–43 × 8–10 μm; basidioles numerous, in shape similar to basidia but smaller.

***Spores*.** Basidiospores ellipsoid to broadly ellipsoid, colorless, thin-walled, smooth, IKI+, CB–, (8–)8.5–11 × (5.5–)6–7.5 μm, L = 9.69 μm, W = 6.66 μm, Q = 1.46–1.58 (n = 60/2).

Additional specimen examined (paratype). China. • Yunnan Province: Zhaotong, Daguan County, Huanglianhe Scenic Spot, GPS coordinates: 27°72'N, 103°92'E, altitude: 1480 m asl., on the fallen angiosperm branch, leg. C.L. Zhao, 3 Jul 2023, CLZhao 29390, GenBank: ITS = PQ166603, nLSU = PQ295862 (SWFC!).

***Gloeocystidiellum cremeum* L. Wang & C.L. Zhao, sp. nov.**
MycoBank No: 855873
Figs 7, 8

Holotype. China. • Yunnan Province: Zhaotong, Wumengshan National Nature Reserve, GPS coordinates: 27°77'N, 104°25'E, altitude: 1900 m asl., on the fallen angiosperm branch, leg. C.L. Zhao, 20 Sep 2023, CLZhao 33623, GenBank: ITS = PQ287847, nLSU = PQ295864 (SWFC!).

Diagnosis. It is characterized by cream membranaceous basidiomata, a monomitic hyphal system with clamped generative hyphae, thick-walled, subcylindrical to obclavate gloeocystidia, and ellipsoid to subglobose basidiospores.

Etymology. *Cremeum* (Lat.): refers to the species having a cream color of the hymenial surface.

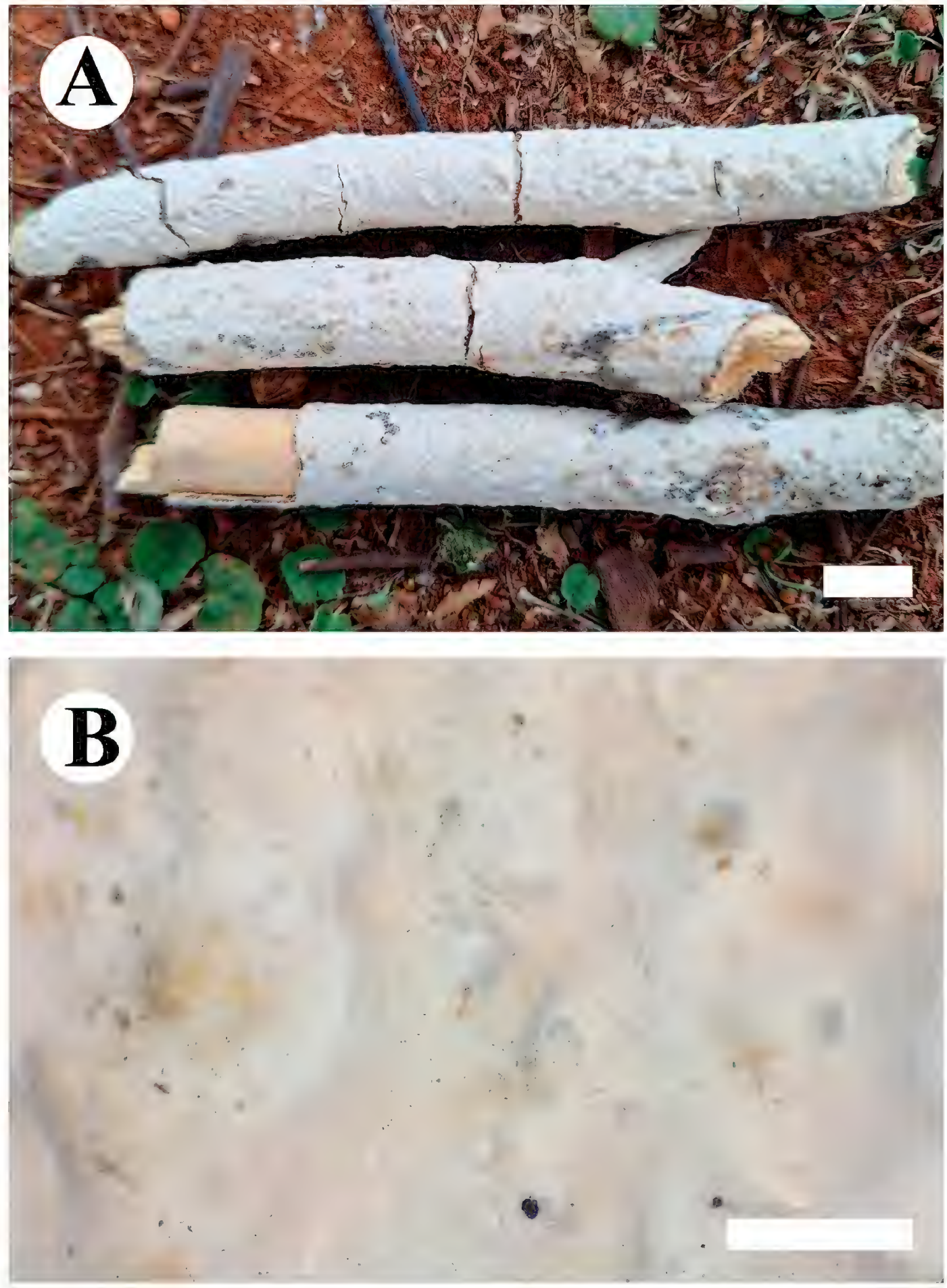

Figure 5. Basidiomata of *Conferticium tuberculatum* (holotype CLZhao 29376). Scale bars: 1 cm (**A**); 1 mm (**B**).

Description. ***Basidiomata*****.** Annual, resupinate, closely adnate, membranaceous, without odor or taste when fresh, up to 8.5 cm long, 2 cm wide, and 300 μm thick. Hymenophore smooth, white when fresh, white to cream upon drying. Sterile margin cream, up to 1 mm.

Hyphal system**.** Monomitic; generative hyphae with clamp connections, colorless, thin-walled, smooth, branched, interwoven, 2–3 μm in diameter, IKI–, CB–; tissues unchanged in KOH.

Hymenium**.** Gloeocystidia numerous, variable in size and shape, subcylindrical to obclavate, colorless, slightly thick-walled, smooth, mostly 70–77 × 7.5–10.5 μm. Basidia subcylindrical to subclavate, slightly flexuous, with a basal clamp connection and four sterigmata, 19–24 × 3–4.5 μm; basidioles numerous, in shape similar to basidia but smaller.

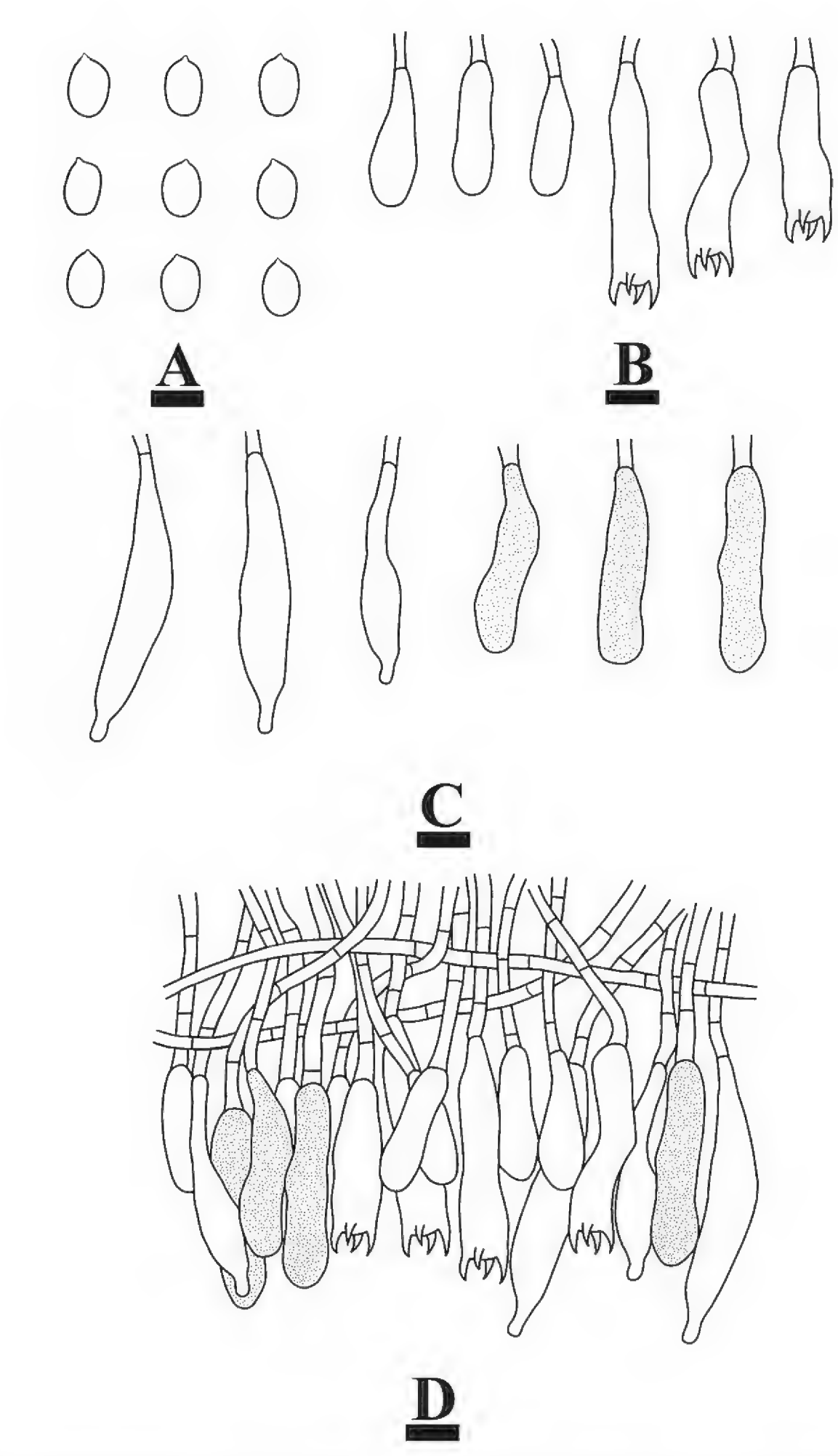

Figure 6. Microscopic structures of *Conferticium tuberculatum* (holotype CLZhao 29376): basidiospores (**A**); basidia and basidioles (**B**); gloeocystidia (**C**); a section of the hymenium (**D**). Scale bars: 10 μm (**A–D**).

***Spores*.** Basidiospores ellipsoid to subglobose, colorless, thin-walled, smooth, IKI+, CB−, (3.5−)4−5 × (2−)2.5−3.5 μm, L = 4.41 μm, W = 2.97 μm, Q = 1.39−1.51 (n = 90/3).

Additional specimens examined (paratypes). CHINA. • Yunnan Province: Zhaotong, Weixin County, Tianxing National Forest Park, GPS coordinates: 28°05'N, 105°09'E, altitude: 900 m asl., on the fallen angiosperm branch, leg. C.L. Zhao, 5 Jul 2023, CLZhao 29477, GenBank: ITS = PQ287846, nLSU = PQ295863; • Zhaotong, Wumengshan National Nature Reserve, GPS coordinates: 27°77'N, 104°25'E, altitude: 1900 m asl., on the fallen angiosperm branch, leg. C.L. Zhao, 20 Sep 2023, CLZhao 33690, GenBank: ITS = PQ287848 (SWFC!).

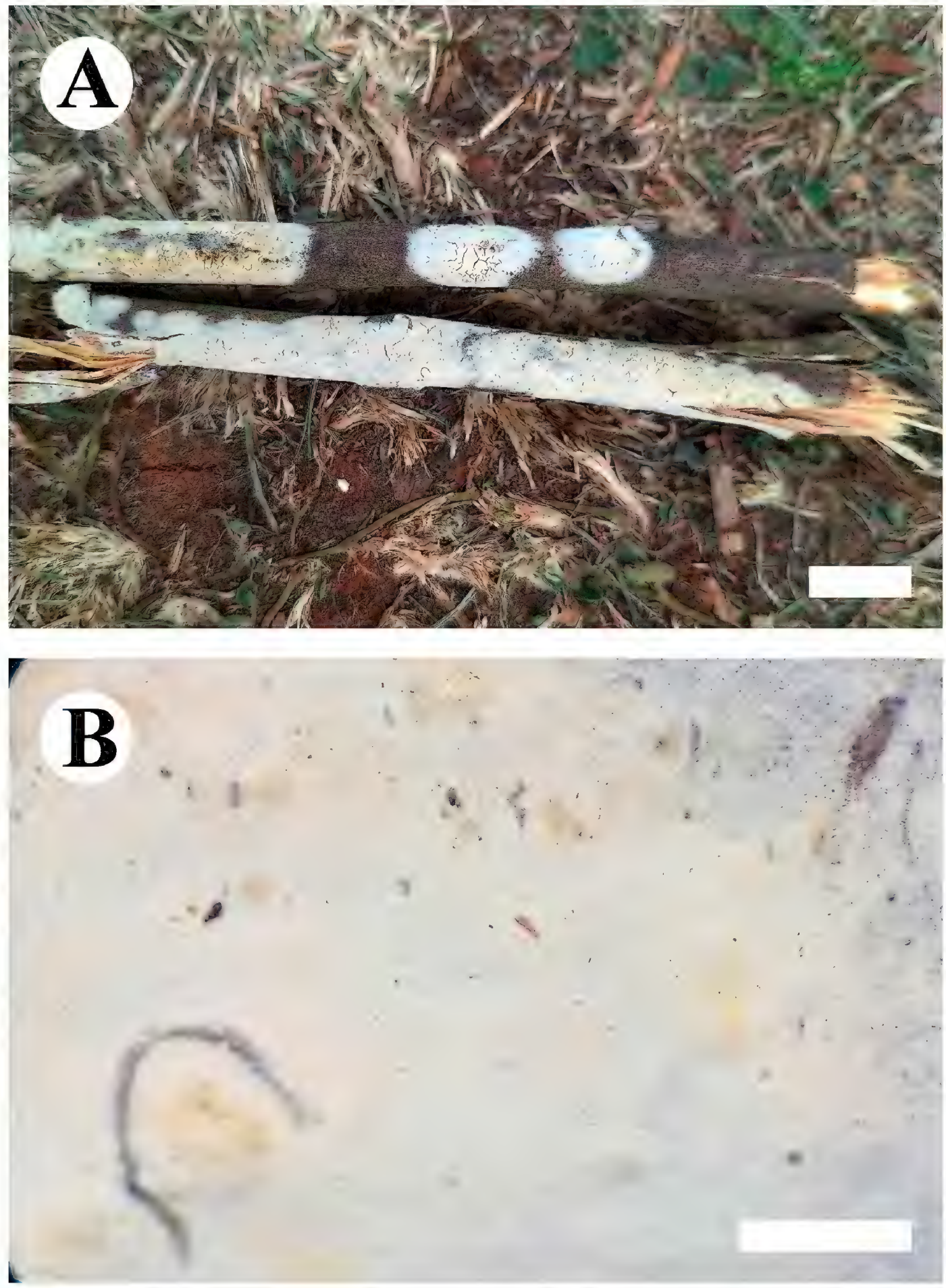

Figure 7. Basidiomata of *Gloeocystidiellum cremeum* (holotype CLZhao 33623). Scale bars: 1 cm (**A**); 1 mm (**B**).

Gloeocystidiellum fissuratum **L. Wang & C.L. Zhao, sp. nov.**

MycoBank No: 855874

Figs 9, 10

Holotype. CHINA. • Yunnan Province: Zhaotong, Wumengshan National Nature Reserve, GPS coordinates: 27°77'N, 104°25'E, altitude: 1900 m asl., on the fallen angiosperm branch, leg. C.L. Zhao, 28 Aug 2023, CLZhao 32498, GenBank: ITS = PQ287851 (SWFC!).

Diagnosis. It is characterized by white to cinnamon-buff, membranaceous basidiomata with grandinioid and cracking hymenophore surfaces, a monomitic hyphal system with clamped generative hyphae, numerous, variable in size and shape gloeocystidia, and subglobose basidiospores.

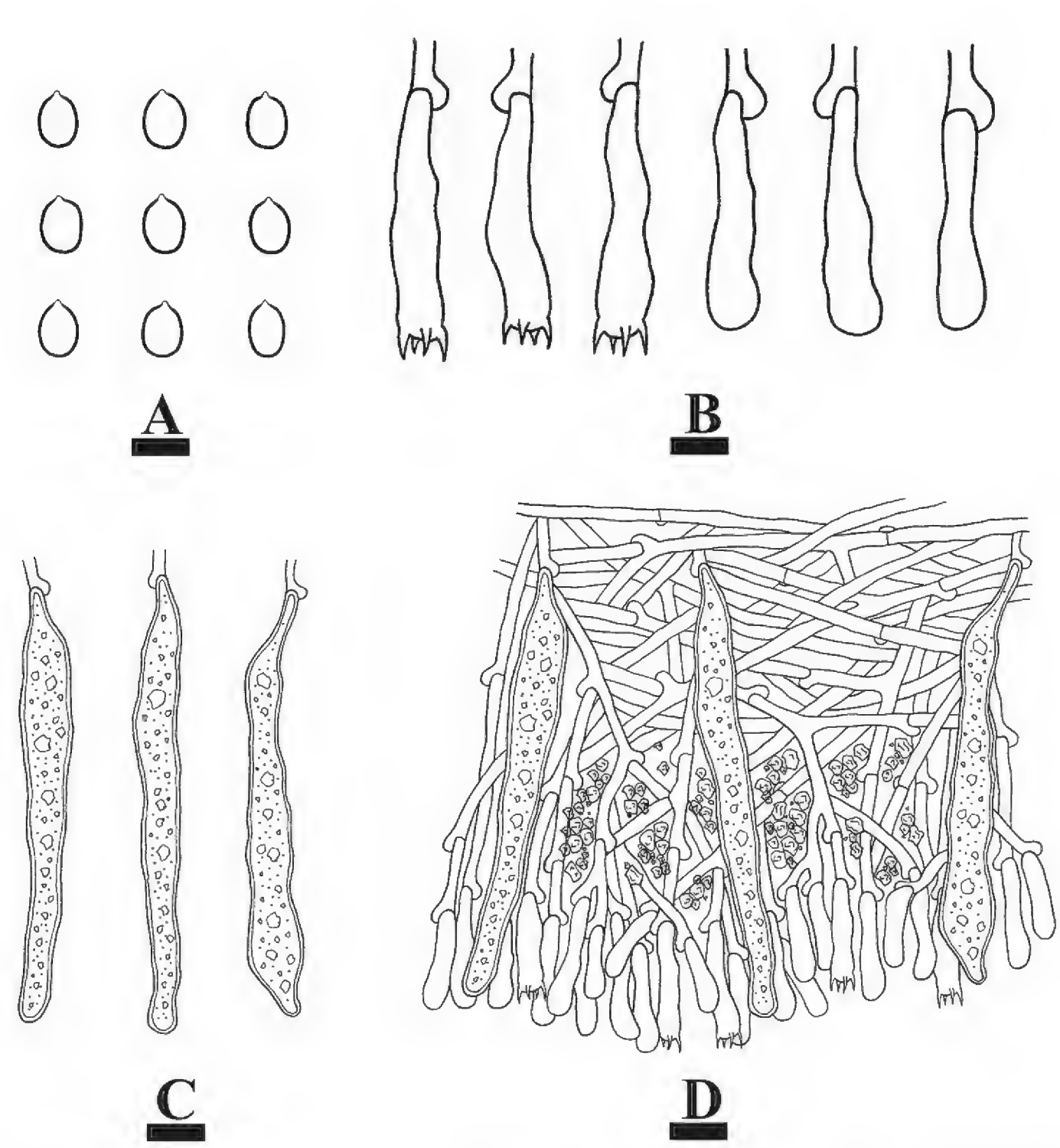

Figure 8. Microscopic structures of *Gloeocystidiellum cremeum* (holotype CLZhao 33623): basidiospores (**A**); basidia and basidioles (**B**); gloeocystidia (**C**); a section of the hymenium (**D**). Scale bars: 5 µm (**A, B**); 10 µm (**C, D**).

Etymology. *Fissuratum* (Lat.): refers to the species having a cracking hymenial surface.

Description. ***Basidiomata*.** Annual, resupinate, closely adnate, membranaceous, without odor or taste when fresh, up to 8.5 cm long, 2 cm wide, and 300 µm thick. Hymenophore grandinioid, cracking, white to cinnamon-buff when fresh, cinnamon-buff upon drying. Sterile margin cream, up to 2 mm.

***Hyphal system*.** Monomitic; generative hyphae with clamp connections, colorless, thin-walled, smooth, branched, interwoven, 2–3 µm in diameter, IKI–, CB–; tissues unchanged in KOH.

***Hymenium*.** Gloeocystidia numerous, variable in size and shape, subclavate to obclavate, colorless, thin-walled, smooth, mostly 57–88 × 9–10 µm. Basidia subcylindrical to subclavate, slightly flexuous, with a basal clamp connection and four sterigmata, 13–16 × 4–5 µm; basidioles numerous, in shape similar to basidia but smaller.

***Spores*.** Basidiospores subglobose, colorless, thin-walled, verrucose, IKI+, CB–, (3–)3.5–4.5(–5) × 2.5–3.5(–4) µm, L = 4.04 µm, W = 3.06 µm, Q = 1.26–1.32 (n = 90/3).

Additional specimens examined (paratypes). China. • Yunnan Province: Zhaotong, Wumengshan National Nature Reserve, GPS coordinates: 27°77'N, 104°25'E, altitude: 1900 m asl., on angiosperm stump, leg. C.L. Zhao, 28 Aug

Figure 9. Basidiomata of *Gloeocystidiellum fissuratum* (holotype CLZhao 32498). Scale bars: 1 cm (**A**); 1 mm (**B**).

2023, CLZhao 32247, GenBank: ITS = PQ287849; nLSU = PQ295865; on the fallen branch of *Picea*, leg. C.L. Zhao, 28 Aug 2023, CLZhao 32303, GenBank: ITS = PQ287850, nLSU = PQ295866 (SWFC!).

Peniophora albohymenia **L. Wang & C.L. Zhao, sp. nov.**

MycoBank No: 855875

Figs 11, 12

Holotype. China. • Yunnan Province: Zhaotong, Fenghuangshan National Forest Park, GPS coordinates: 27°30'N, 103°70'E, altitude: 1950 m asl., on the fallen angiosperm branch, leg. C.L. Zhao, 24 Aug 2022, CLZhao 23473, GenBank: ITS = PQ066419, nLSU = PQ295867 (SWFC!).

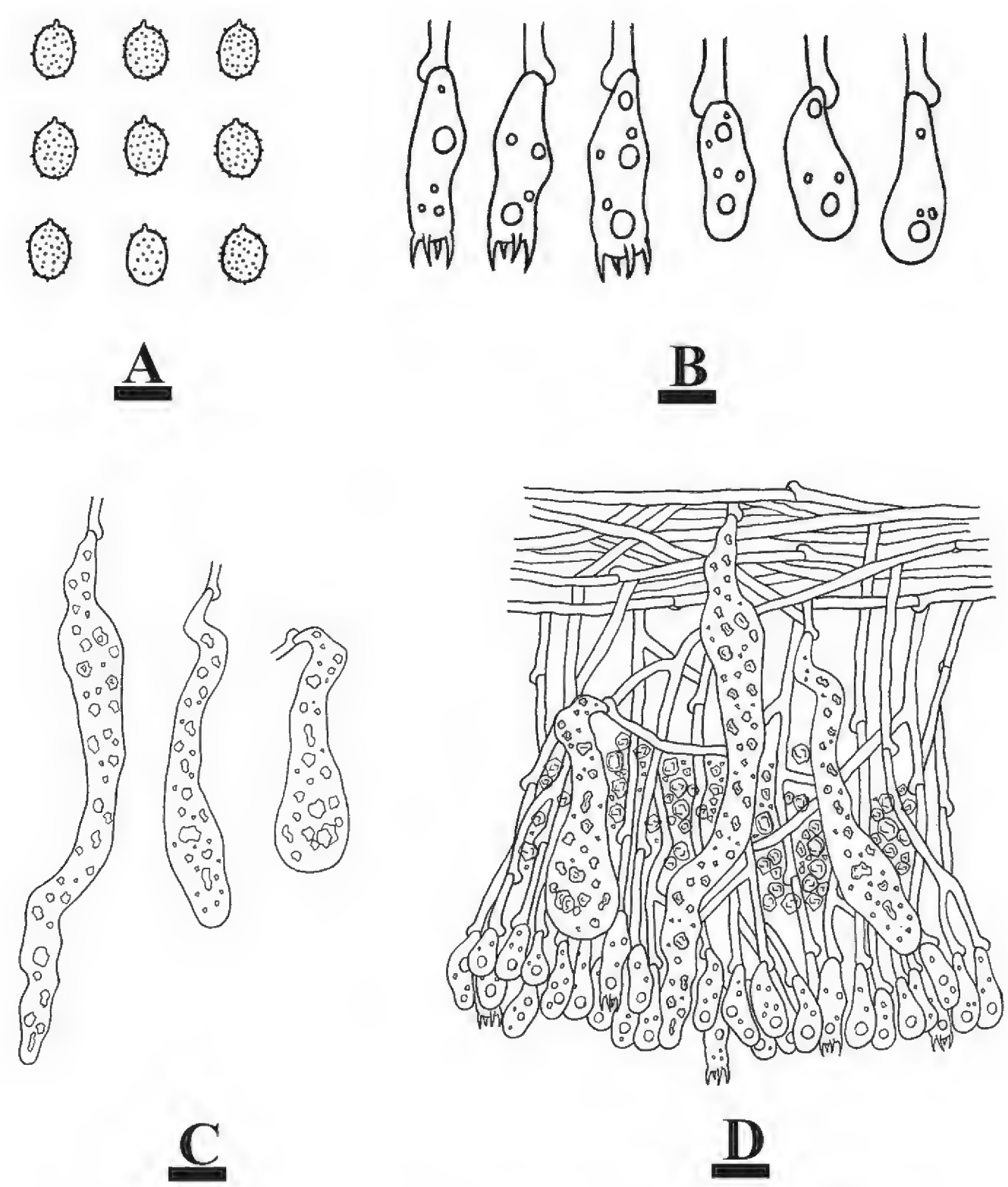

Figure 10. Microscopic structures of *Gloeocystidiellum fissuratum* (holotype CLZhao 32498): basidiospores (**A**); basidia and basidioles (**B**); gloeocystidia (**C**); a section of the hymenium (**D**). Scale bars: 5 µm (**A, B**); 10 µm (**C, D**).

Diagnosis. It is characterized by white to pale pink, smooth membranaceous basidiomata, a monomitic hyphal system with simple-septa generative hyphae, and allantoid to cylindrical basidiospores.

Etymology. *Albohymenia* (Lat.): refers to the species having white basidiomata.

Description. ***Basidiomata*.** Annual, resupinate, closely adnate, membranaceous, without odor or taste when fresh, up to 9 cm long, 3.5 cm wide, and 300 µm thick. Hymenophore smooth, white when fresh, white to pale pink upon drying. Sterile margin narrow, white, up to 1 mm.

***Hyphal system*.** Monomitic; generative hyphae with simple-septa, colorless, slightly thick-walled, smooth, rarely branched and septate, more or less parallel to substrate, 4–4.5 µm in diameter, IKI–, CB–; tissues unchanged in KOH.

***Hymenium*.** Cystidia of two types: (1) Gloeocystidia fusiform, flexuous, colorless, thin-walled, smooth, 31.5–35.5 × 6–7 µm; (2) Lamprocystidia abundant, subulate to subcylindrical, heavily encrusted with crystals in the middle and upper parts, thin-walled, colorless, embedded or projecting beyond the hymenium, with a basal simple-septum, 31–42 × 10–13.5 µm. Basidia subcylindrical to subclavate, slightly flexuous, with a basal simple septum and four

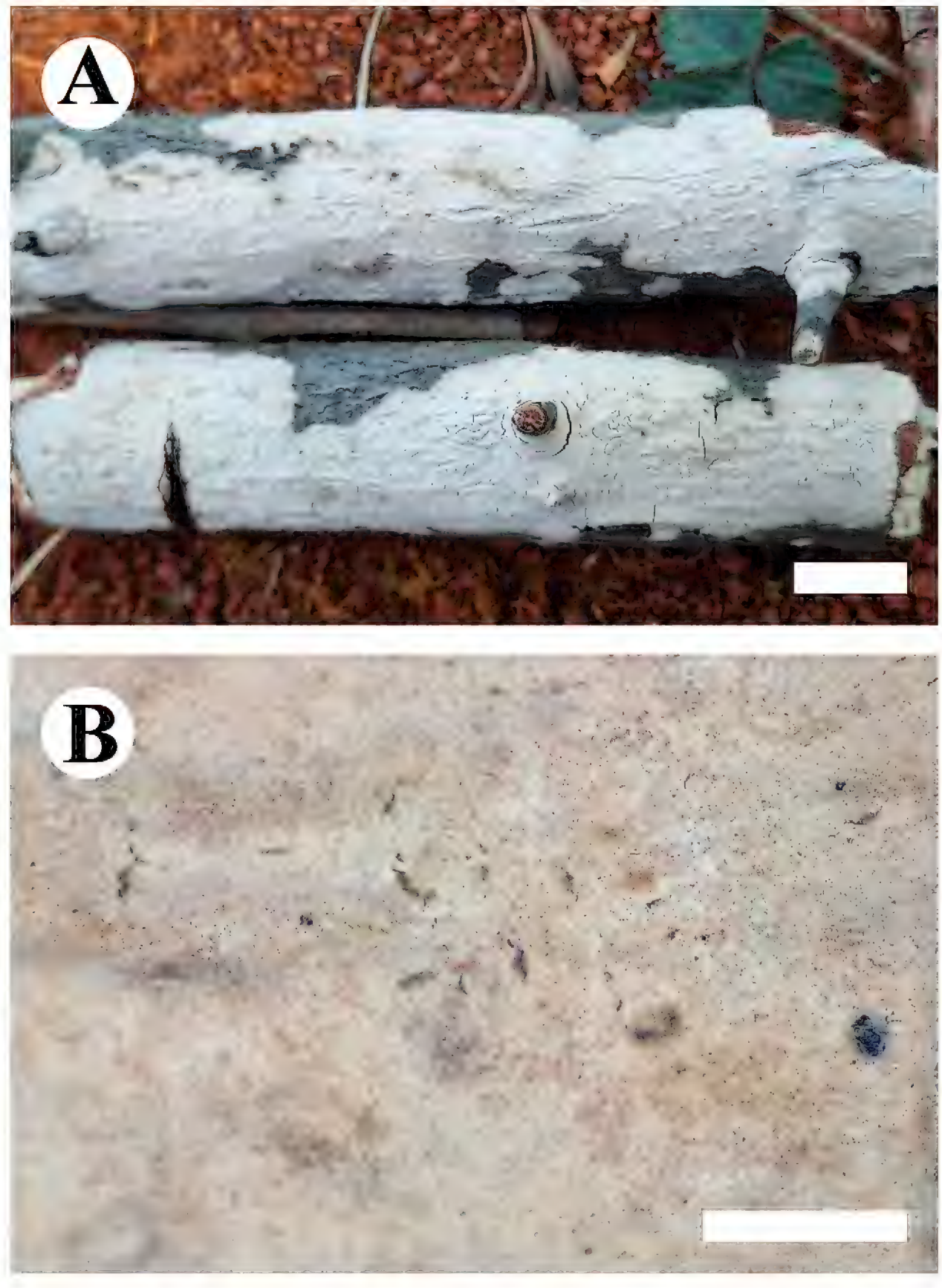

Figure 11. Basidiomata of *Peniophora albohymenia* (holotype CLZhao 23473). Scale bars: 1 cm (**A**); 1 mm (**B**).

sterigmata, 23.5–26 × 4.5–6 µm; basidioles numerous, in shape similar to basidia but slightly smaller.

***Spores*.** Basidiospores allantoid to cylindrical, colorless, thin-walled, smooth, IKI–, CB–, (7–)8.5–11(–11.5) × 3–4.5(–5) µm, L = 9.65 µm, W = 3.93 µm, Q = 2.46 (n = 30/1).

Peniophora hengduanensis L. Wang & C.L. Zhao, sp. nov.

MycoBank No: 855876

Figs 13, 14

Holotype. China. • Yunnan Province: Diqing, Weixi County, Zhonglu Town, GPS coordinates: 27°16'N, 99°15'E, altitude: 2250 m asl., on the fallen angiosperm branch, leg. C.L. Zhao, 14 Oct 2022, CLZhao 34697, GenBank: ITS = PQ066422, nLSU = PQ295870 (SWFC!).

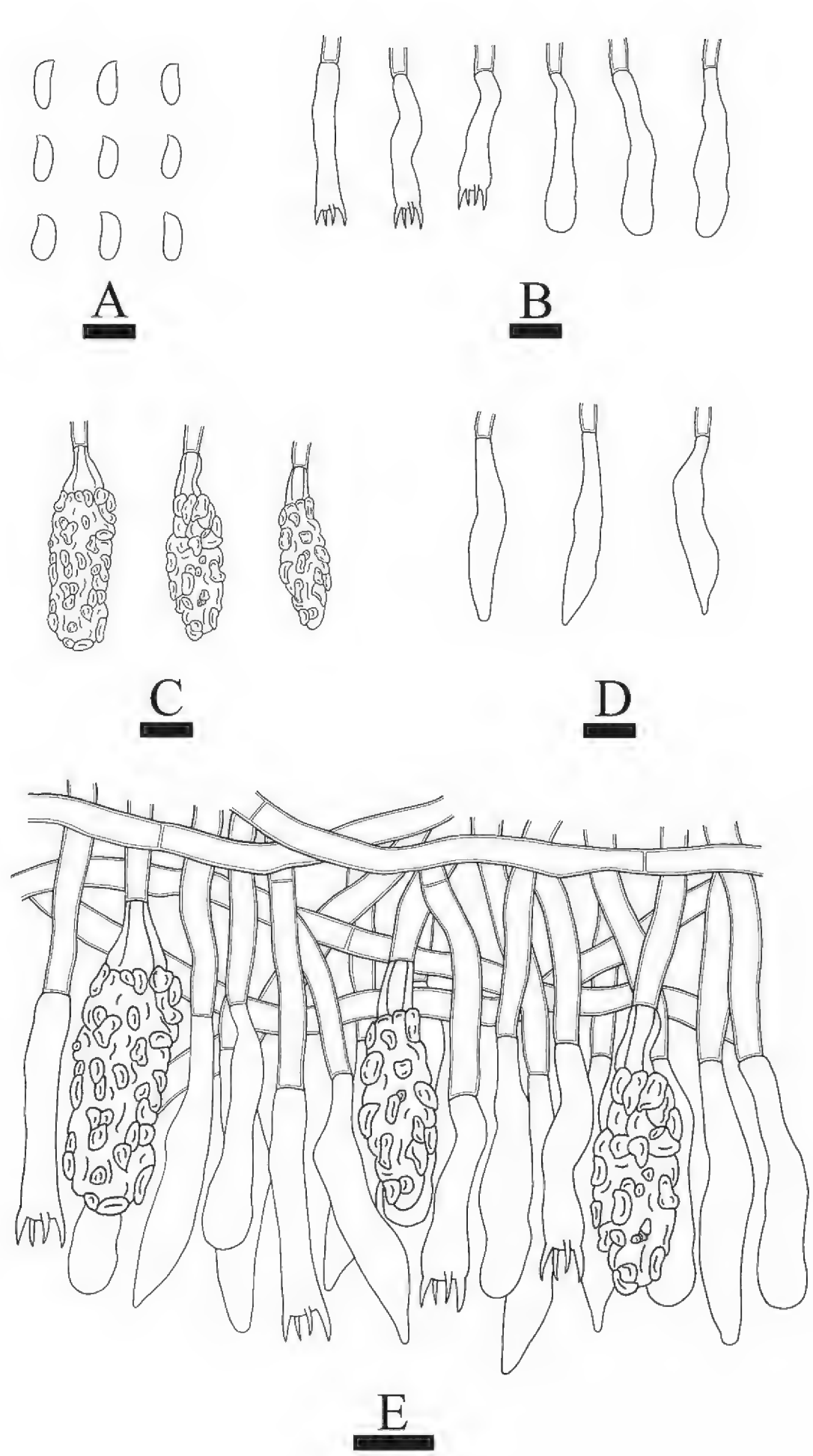

Figure 12. Microscopic structures of *Peniophora albohymenia* (holotype CLZhao 23473): basidiospores (**A**); basidia and basidioles (**B**); lamprocystidia (**C**); gloeocystidia (**D**); a section of the hymenium (**E**). Scale bars: 10 μm (**A–E**).

Diagnosis. It is characterized by pink to vinaceous, smooth membranaceous basidiomata, a monomitic hyphal system with simple-septa, and allantoid to subcylindrical basidiospores.

Etymology. *Hengduanensis* (Lat.): refers to the locality (Hengduan Mountains) of the type specimen.

Description. *Basidiomata*. Annual, resupinate, closely adnate, membranaceous, without odor or taste when fresh, up to 7.5 cm long, 4 cm wide, and 400 μm thick. Hymenophore smooth, pale pink when fresh, pink to vinaceous upon drying. Sterile margin narrow, white to vinaceous, up to 1 mm.

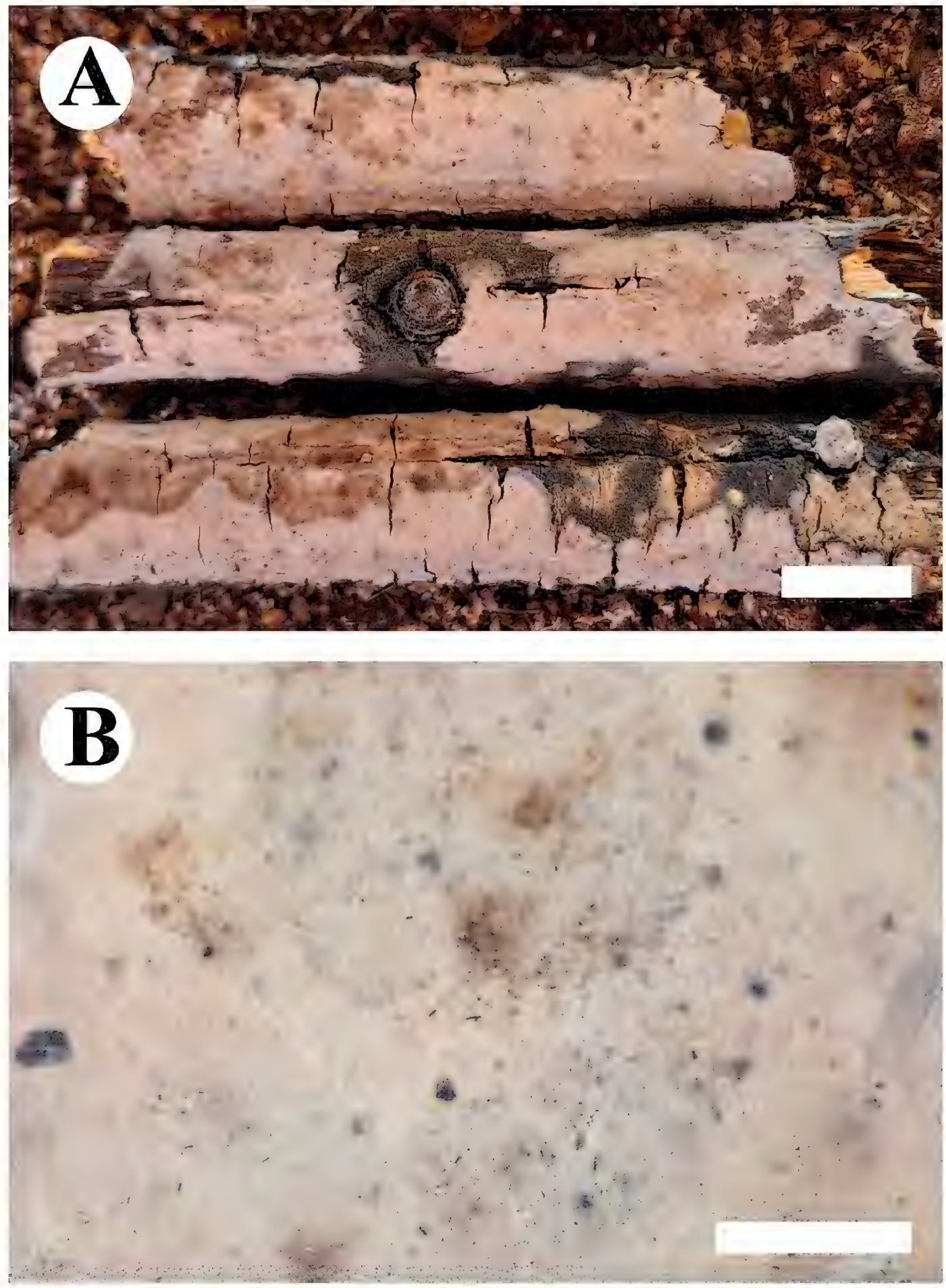

Figure 13. Basidiomata of *Peniophora hengduanensis* (holotype CLZhao 34697). Scale bars: 1 cm (**A**); 1 mm (**B**).

***Hyphal system*.** Monomitic; generative hyphae with simple-septa, colorless, thin-walled, smooth, rarely branched, rarely septate, more or less parallel to substrate, 3.5–4.5 µm in diameter, IKI–, CB–; tissues unchanged in KOH.

***Hymenium*.** Cystidia of two types: (1) Gloeocystidia obclavate, colorless, slightly thick-walled, smooth, 50.5–66 × 11–14.5 µm; (2) Lamprocystidia abundant, subulate to subcylindrical, heavily encrusted with crystals in the middle and upper parts, thin-walled, colorless, embedded or projecting beyond the hymenium, with a basal simple septum, 21.5–25 × 9.5–11 µm. Basidia subcylindrical to subclavate, slightly flexuous, with a basal simple septum and four sterigmata, 20–32.5 × 4.5–6 µm; basidioles numerous, in shape similar to basidia but slightly smaller.

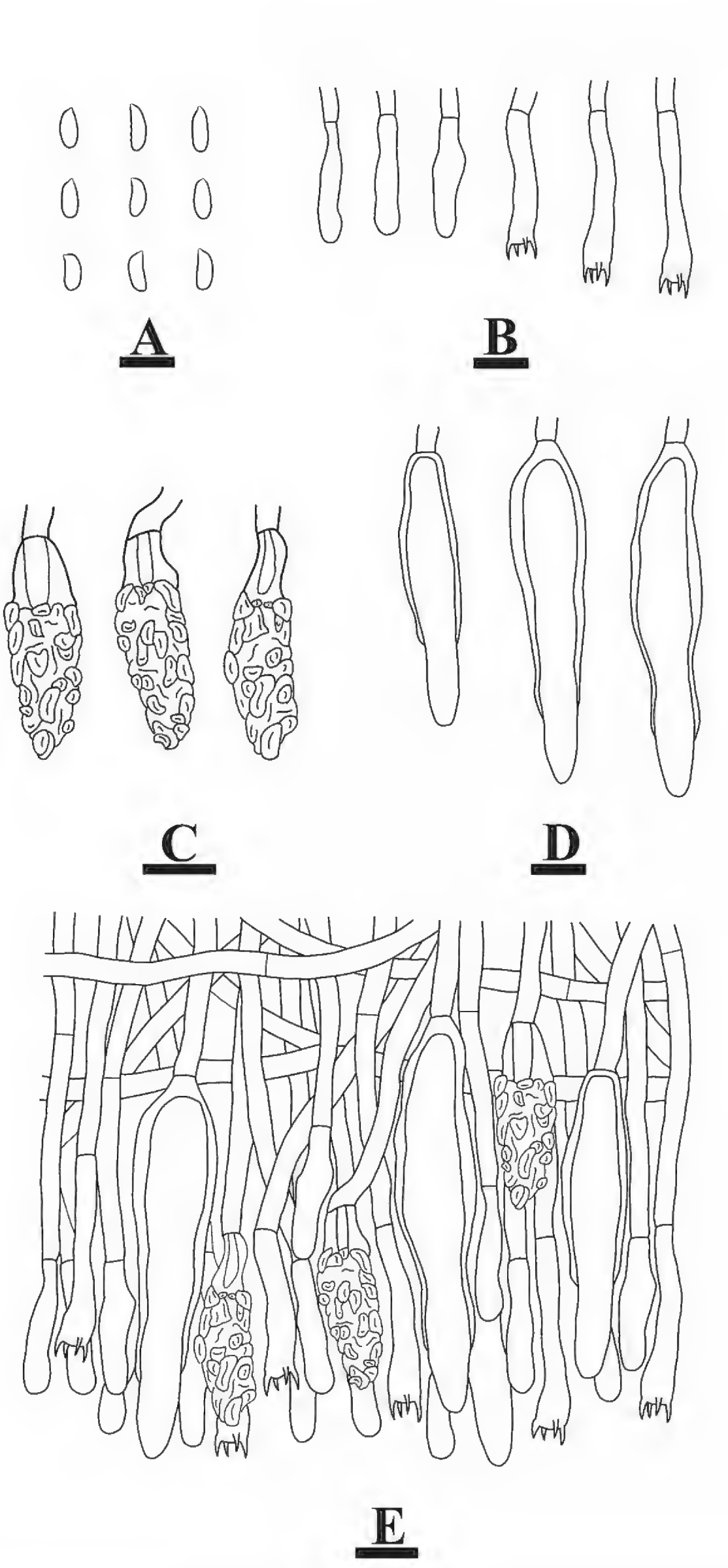

Figure 14. Microscopic structures of *Peniophora hengduanensis* (holotype CLZhao 34697): basidiospores (**A**); basidia and basidioles (**B**); lamprocystidia (**C**); gloeocystidia (**D**); a section of the hymenium (**E**). Scale bars: 10 μm (**A–E**).

***Spores*.** Basidiospores allantoid to subcylindrical, colorless, thin-walled, smooth, IKI−, CB−, (6−)6.5–8.5(−9) × 2.5–3.5(−4) μm, L = 7.35 μm, W = 3.15 μm, Q = 2.33 (n = 30/1).

Peniophora punctata **L. Wang & C.L. Zhao, sp. nov.**
MycoBank No: 855877
Figs 15, 16

Holotype. CHINA. • Yunnan Province: Zhaotong, Xiaocaoba, Wumengshan National Nature Reserve, GPS coordinates: 27°77'N, 104°25'E, altitude: 1900 m asl., on the fallen angiosperm branch, leg. C.L. Zhao, 21 Sep 2023, CLZhao 33769, GenBank: ITS = PQ066418 (SWFC!).

Diagnosis. It is characterized by pink to slightly purple, cushion-shaped, smooth membranaceous basidiomata, a monomitic hyphal system with simple-septa, thick-walled generative hyphae, and allantoid basidiospores.

Etymology. *Punctata* (Lat.): refers to the species having cushion-shaped basidiomata.

Description. ***Basidiomata*****.** Annual, resupinate, closely adnate, cushion-shaped, membranaceous, without odor or taste when fresh, up to 3 cm long, 1.5 cm wide, and 300 μm thick. Hymenophore smooth, pink to slightly purple when fresh, purple upon drying. Sterile margin narrow, white to vinaceous, up to 1 mm.

Hyphal system**.** Monomitic; generative hyphae with simple-septa, colorless, slightly thick-walled, smooth, rarely branched, rarely septate, more or less parallel to substrate, 2.5–3.5 μm in diameter, IKI–, CB–; tissues unchanged in KOH.

Hymenium**.** Cystidia of two types: (1) Gloeocystidia fusiform or subclavate, slightly flexuous, colorless, slightly thick-walled, smooth, 31.5–51.5 × 6–8 μm; (2) Lamprocystidia abundant, subulate to subcylindrical, heavily encrusted with crystals in the middle and upper parts, thin-walled, colorless, embedded or projecting beyond the hymenium, with a basal simple septum, 36–39 × 8.5–12.5 μm. Basidia subcylindrical to subclavate, slightly flexuous, with a basal simple septum and four sterigmata, 18–21.5 × 3–4.5 μm; basidioles numerous, in shape similar to basidia but slightly smaller.

Spores**.** Basidiospores allantoid, colorless, thin-walled, smooth, IKI–, CB–, 5–7(–7.5) × 1.5–2.5 μm, L = 6.08 μm, W = 2.22 μm, Q = 2.73 (n = 30/1).

Discussion

A large number of studies were focused on the taxonomy and phylogeny of Russulales taxa in the last ten years (He et al. 2019; Wijayawardene et al. 2022; Wu et al. 2020; Zou et al. 2022; Li et al. 2023; Deng et al. 2024b; Dong et al. 2024; Liu et al. 2024; Zhou et al. 2024). Both families, Peniophoraceae and Stereaceae, are well-supported large groups in Russulales, and most species have resupinate and effused-reflexed basidiomata growing on fallen twigs, branches, or trunks of woody plants or bamboos (Larsson and Larsson 2003; Miller et al. 2006; Zhou and Dai 2013; De Crop et al. 2016; He et al. 2024). Molecular analyses have elucidated the evolutionary relationships, in which the findings demonstrate significant morphological changes occurring at both the levels of family and genus (Larsson and Larsson 2003; Miller et al. 2006; Zhao et al. 2017; He et al. 2019; Wu et al. 2020). Elucidating morphological differences for its overall appearance, structure, colors, spore characters, and hyphal structure, as well as its habitat, this distinction holds significant importance for making phylogenetic and systematic conclusions (Miller et al. 2006; Dong et al. 2024; He et al. 2024).

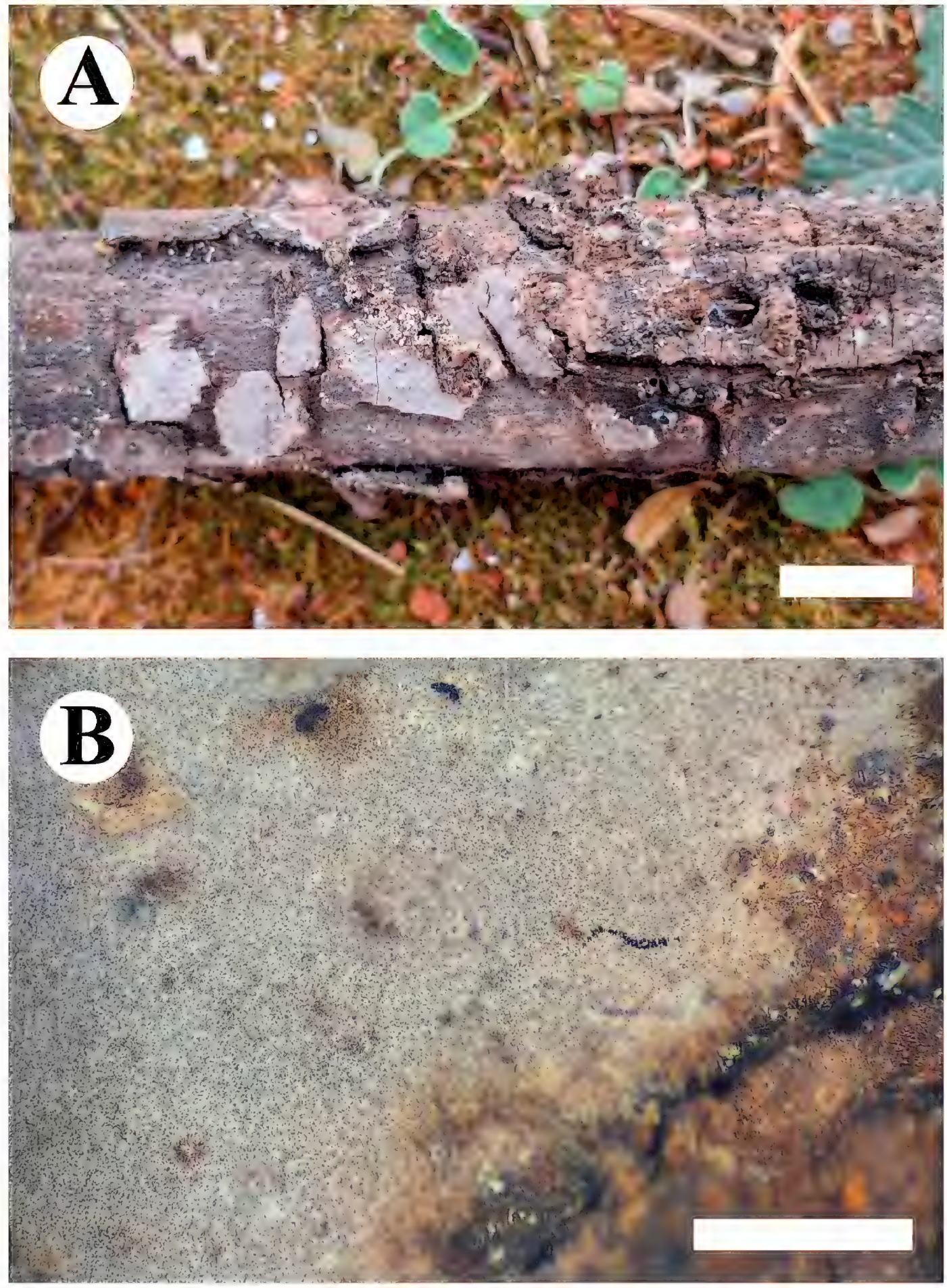

Figure 15. Basidiomata of *Peniophora punctata* (holotype CLZhao 33769). Scale bars: 1 cm (**A**); 1 mm (**B**).

Phylogenetically, the multiple genes with ITS+nLSU analysis showed that the six new species grouped within the order Russulales, in which *Conferticium tuberculatum*, *Gloeocystidiellum cremeum*, and *G. fissuratum* grouped into the family Stereaceae. *Conferticium tuberculatum* is separated from closely related species *C. ravum*, which can be delimited from *C. tuberculatum* by its smooth, yellowish to isabelline hymenophore, shorter basidia (20–30 × 4–6 µm), and ellipsoid to ovoid, verrucose basidiospores (6–7 × 4–4.5 µm; Bernicchia and Gorjón 2010). Based on the ITS+nLSU sequence data (Fig. 2), *Gloeocystidiellum cremeum* is grouped with *G. fissuratum* L. Wang & C.L. Zhao and *G. yunnanense* Y.L. Zhao & C.L. Zhao in the *Gloeocystidiellum* clade. However, *G. fissuratum* differs from *G. cremeum* by its white to cinnamon-buff, grandinioid, and cracking hymenophore and smaller basidia (13–16 × 4–5 µm); *G. yunnanense*

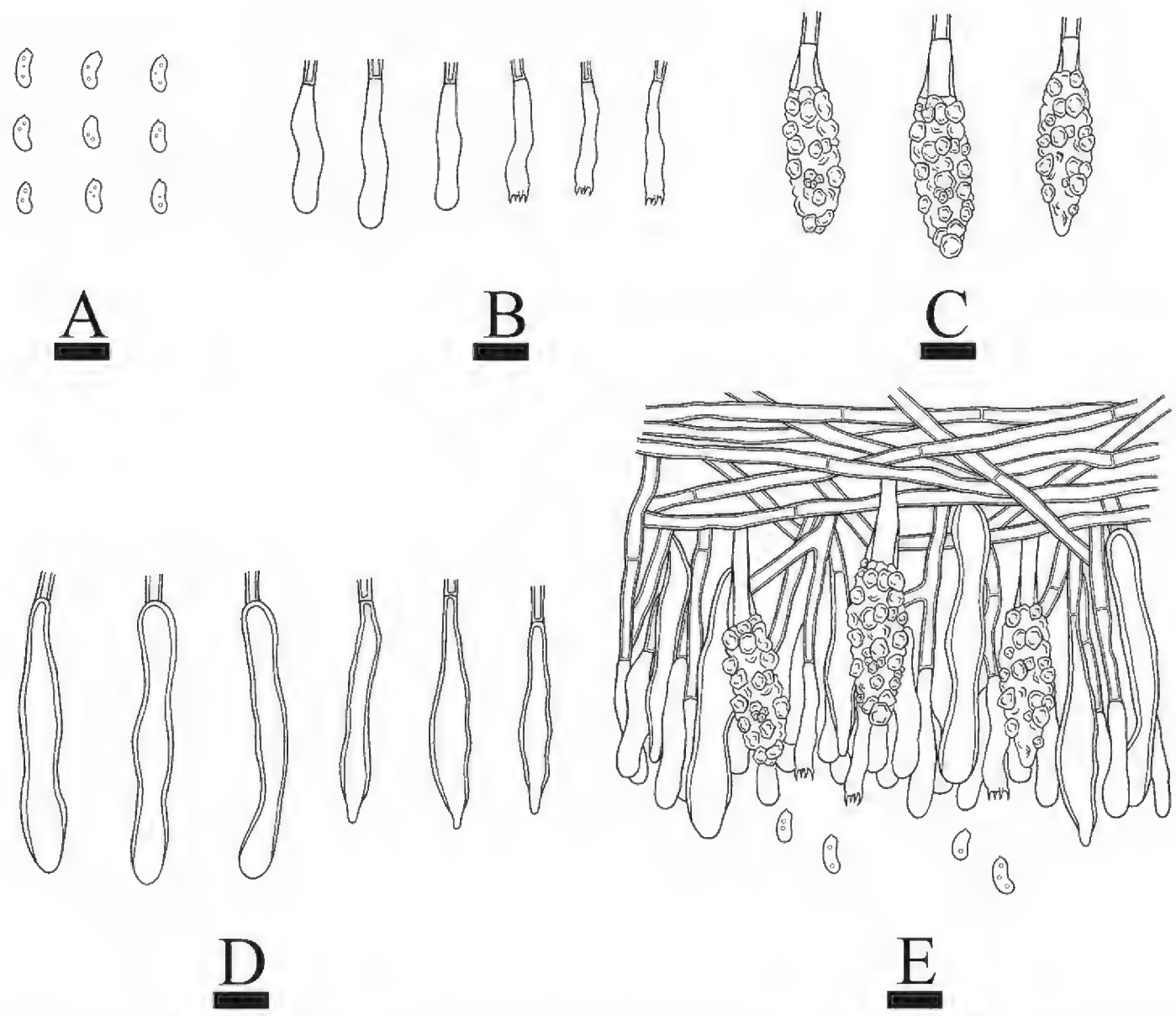

Figure 16. Microscopic structures of *Peniophora punctata* (holotype CLZhao 33769): basidiospores (**A**); basidia and basidioles (**B**); lamprocystidia (**C**); gloeocystidia (**D**); a section of the hymenium (**E**). Scale bars: 10 µm (**A–E**).

is distinguished from *G. cremeum* by its cream, ceraceous, and grandinioid hymenophore, smaller basidia (12.5–14.5 × 3.5–4.5 µm), and slightly thick-walled, aculeate, ellipsoid basidiospores (Zhao and Zhao 2023). *Gloeocystidiellum fissuratum* is distinguished from *G. yunnanense* by cream, ceraceous, and grandinioid hymenophore, smaller basidia (12.5–14.5 × 3.5–4.5 µm), and slightly thick-walled, aculeate, ellipsoid basidiospores (Zhao and Zhao 2023).

Based on the ITS+nLSU analysis, three new taxa, *Peniophora albohymenia*, *P. hengduanensis*, and *P. punctata*, were grouped into the family Peniophoraceae. As inferred from the sequence data (Fig. 4), *Peniophora albohymenia* is a sister of *P. reidii* Boidin & Lanq. However, *P. reidii* is distinguished from *P. albohymenia* by its pinkish gray to gray basidiomata and longer gloeocystidia (25–75 × 5.5–7.5 µm; Boidin and Lanquetin 1983). Based on the ITS+nLSU sequence data (Fig. 4), *Peniophora hengduanensis* formed a sister group with *P. crassitunicata* Boidin, Lanq. However, *P. crassitunicata* is distinguished from *P. hengduanensis* by its pinkish gray to grayish violaceous basidiomata, thick-walled generative hyphae, and bigger, very thick-walled (2–3 µm) gloeocystidia (60–115 × 8–15 µm) (Boidin and Lanquetin 1983). *Peniophora punctata* is a closely related species, viz., *P. borbonica* Boidin, Lanq, and *P. laxitexta* C.E. Gómez. However, *P. borbonica* is delimited from *P. punctata* by its smooth, purplish gray or gray hymenophore, longer gloeocystidia (30–60 × 7–12 µm), and suballantoid to cylindrical, bigger basidiospores (8–10.5 × 2.7–3.5 µm; Boidin and Gilles 2000); *P. laxitexta* can be distinguished from *P. punctata* by its longer basidia (27–35 × 4.5–6 µm) and bigger lamprocystidia (30–60 × 10–22 µm; Gómez and Loewenbaum 1976).

Morphologically, *Conferticium ochraceum* (Fr.) Hallenb. is similar to *C. tuberculatum* by having smooth ceraceous basidiomata. However, *C. ochraceum* differs in its coriaceous basidiomata with pale yellowish hymenophore surface and subcylindrical to subovate basidiospores (4–6.5 × 2.5–3.5 µm; Bernicchia and Gorjón 2010). *Gloeocystidiellum clavuligerum* (Höhn. and Litsch.) Nakasone and *G. porosum* (Berk. and M.A. Curtis) Donk are similar to *G. cremeum* by both having ellipsoid to subglobose basidiospores. However, *G. clavuligerum* differs in its gloeocystidia with a more or less constricted to moniliform apex (50–80 × 8–12 µm; Bernicchia and Gorjón 2010); *G. porosum* differs in its bigger gloeocystidia (80–200 × 8–15 µm, Bernicchia and Gorjón 2010). *Gloeocystidiellum clavuligerum* and *G. porosum* are similar to *G. fissuratum* by both having verrucose, thin-walled basidiospores. However, *G. clavuligerum* differs in its longer basidia (25–30 × 4–5 µm; Bernicchia and Gorjón 2010); *G. porosum* differs in its bigger gloeocystidia (80–200 × 8–15 µm; Bernicchia and Gorjón 2010).

Morphologically, *Peniophora roseoalba* L. Zou & C.L. Zhao and *P. shenghuae* Y.L. Xu, Yan Tian & S.H. He are similar to *P. albohymenia* by both having fusiform, flexuous gloeocystidia. However, *P. roseoalba* differs in its ellipsoid basidiospores (4–6.5 × 3–5 µm; Zou et al. 2022); *P. shenghuae* differs in its coriaceous basidiomata with a brownish-orange hymenophore surface (Xu et al. 2023). *Peniophora vietnamensis* Y.L. Xu, Y. Tian & S.H. He, and *P. pini* (Schleich. ex DC.) Boidin are similar to *P. hengduanensis* by having subcylindrical basidia. However, *P. vietnamensis* differs in its oblong cylindrical basidiospores (14–17 × 4–6 µm; Xu et al. 2023); *P. pini* differs in its clamped generative hyphae and longer lamprocystidia (25–40 × 5–8 µm; Bernicchia and Gorjón 2010). *Peniophora crassitunicata* Boidin, Lanq. & Gilles, and *P. pithya* (Pers.) J. Erikss. are similar to *P. punctata* by having allantoid basidiospores. However, *P. crassitunicata* differs in its clamped generative hyphae and longer subcylindrical basidia (25–40 × 4.5–6 µm; Andreasen and Hallenberg 2009); *P. pithya* differs in its clamped generative hyphae and longer lamprocystidia (30–70 × 8–15 µm; Bernicchia and Gorjón 2010).

Ecological functions performed by members of the order Russulales include mycorrhizal symbiosis and wood decay, which play an important role in nutrient cycling and decomposition within forest ecosystems (Cui et al. 2019; Wu et al. 2019, 2022; Liu et al. 2023; Dai et al. 2021; Deng et al. 2024b; Hyde et al. 2024; Wang et al. 2024a, b; Zhao et al. 2024). Although in the Basidiomycota, there has been a clear evolutionary trend in the development of different types of basidiomata, the taxonomy and phylogeny of some taxa in the order Russulales are still unresolved (Larsson and Larsson 2003; Miller et al. 2006; He et al. 2019, 2024; Wijayawardene et al. 2022, 2024; Wu et al. 2020; Bhunjun et al. 2024; Dong et al. 2024; Liu et al. 2024). In the present study, these data are also crucial as a supplement to the global knowledge of wood-inhabiting of the order Russulales.

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Contribution, CZ and LW; methodology, CZ and LW; software, LW, Sana J and CZ; validation, CZ and Sana J; formal analysis, CZ, SH, and LW; investigation, CZ and LW; resources CZ; writing—original draft preparation, LW, SH, YZ, and CZ; writing—review and editing, CZ and LW; visualization, CZ and LW; supervision, CZ; project administration, CZ; funding acquisition, CZ. All authors have read and agreed to the published version of the manuscript.

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Data availability

All of the data that support the findings of this study are available in the main text.

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